A TREATISE ON THE PROTRACTED CASES OF INDIGESTION.

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A

TREATISE

ON

PROTRACTED INDIGESTION

AND

ITS CONSEQUENCES;

BEING THE APPLICATION TO

THE PRACTICAL DEPARTMENT OF MEDICINE

OF

THE RESULTS OF AN INQUIRY

INTO

THE LAWS OF THE VITAL FUNCTIONS:

ADDRESSED BY THE AUTHOR, ON HIS RETIREMENT FROM
THE MEDICAL PROFESSION,

BOTH TO THE MEMBERS OF THAT PROFESSION,
AND TO THE WELL-EDUCATED PUBLIC,
PARTICULARLY PARENTS.

BY

A. P. W. PHILIP, M.D. F.R.S.
LONDON AND EDINBURGH,
FELLOW OF THE ROYAL COLLEGES OF PHYSICIANS OF LONDON AND
EDINBURGH, ETC.

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PREFACE.

Had I remained in the medical profession, I should not have published such a work as the following, which I have been for a considerable time preparing for the press, with the view of retiring from that profession.

There is generally but one motive for members of the medical profession addressing the public respecting the cure of diseases. When this is done, it is justly considered discreditable. The party addressed is confessedly incapable of judging of the accuracy of what is said; and those who adopt such a course are generally men who have failed, by a knowledge of their profession, and a regular performance of its duties, to obtain the public confidence. As might be expected, therefore, they are generally the least capable of the task they have undertaken.

I address the public, I hope I may be permitted to say, under wholly different circumstances. I have been extensively engaged in the practice of medicine for between thirty and forty years, and am well known to have devoted much time to the study of the laws of our frame, as appears from twelve papers presented to the Royal Society of London, and published in the Philosophical Transactions, between the beginning of the year 1815 and the end of 1836, four editions of my Inquiry into the Laws of the Vital Functions, and seven editions of my Treatise on Indigestion; the original parts of which publications

rest on certain laws of the animal system, a knowledge of which it will appear, from what I am about to say in this preface, was the result of the inquiry just referred to; and, on the necessary inferences from those laws, what I regard, and is now regarded by many others, as a greatly improved treatment of the class of diseases which forms the subject of this volume, is founded.*

The present edition of my Treatise on Indigestion is, in several respects, very different from the seven editions which preceded it. To these editions, and

* The Inquiry referred to in the text was begun while I was a student at the University of Edinburgh, and continued, as far as the more active duties of my profession permitted, to the end of the year 1836, a period of about forty years, at which time I considered the investigation as completed. My attention was early called to the inconsistencies which prevail respecting the general laws of our frame, and I have, through the greater part of not a short life, been more or less employed in an attempt to remove them; an account of the progress of which the Royal Society of London, as just observed, has from time to time, since the beginning of the year 1815, done me the honour to publish; and in the year 1836, although in opposition to the practice of the Society, it did me the farther honour to recapitulate in the Philosophical Transactions in a more concise form, although the recapitulation occupies a considerable space, the whole of the results of the inquiry which had appeared in its Transactions, for the purpose of bringing them into one view, in order that the necessary inferences from them, when an opportunity is afforded of comparing together the various positions at which I had arrived, might be apparent.

In an Appendix to the present publication, I have been permitted by the Royal Society of London to republish from the Philosophical Transactions the principal facts on which this treatise is founded; which, at the same time that it makes the reader acquainted with those facts, proves that my statements had obtained the sanction of some of the first physiologists of our times, who always form a part of the council of the Royal Society.

particularly to the seventh, which is not yet out of print, I must refer for the symptoms and treatment of ordinary cases of indigestion. The present edition is devoted to the consideration of the nature and tendencies of this disease, when confirmed by continuance, in which state it has, in common language, obtained the name of bilious complaints; but in consequence of the physiological errors which prevail in our profession, without its nature and tendencies having been understood, and consequently a diagnosis between it and common cases of indigestion pointed out; which, from its being the most hereditary disease we are subject to, its great frequency in this country, and the important influence of the liver on all other vital organs, is of far greater consequence than has been supposed, and renders a diagnostic, by which it may be correctly distinguished in each of its different stages, and an appropriate treatment adapted to each of these stages, often necessary to relieve severe suffering, and always so where the suffering has become permanent, which is the usual consequence of its continuance, in order to prevent a more or less distant but at length a rapidly fatal termination.

All medical men of any standing must have seen instances in which, after long-continued and severe suffering, death has rapidly ensued, to their own surprise, as well as that of the friends of the sufferer, without their being able to explain satisfactorily why symptoms, which do not usually indicate such immediate danger, were the only symptoms which immediately preceded the fatal termination. From what is stated in this volume, I trust it will appear in what manner this and other evils which I shall

have occasion to point out, may be referred to the physiological errors at present influencing the practical department of our profession, and by what means these evils may be corrected.

What are commonly called bilious complaints, as well as all other morbid states affecting the brain and spinal marrow, are, strictly speaking, constitutional affections, which, in their various and more severe forms, often degenerate into some of the most fatal diseases to which we are subject; and which are rendered doubly dangerous, as will appear from the relation which subsists between the different stages of such cases, from mistaken views which have arisen respecting some of the most influential laws of our frame.

As the object of this publication is to explain the nature and check the great fatality of such cases, both these subjects are more fully considered in the following pages than in any other of my publications; and as it is necessary for these purposes to enter more fully into the inferences from my physiological investigations than I had previously done, it is on this account that the present volume is addressed to the members of the medical profession, as well as to the public.

The first and only public attempt I have made to enter on the whole of the practical part of the subject was in the fourth edition of my Inquiry into the Laws of the Vital Functions, published in 1839; for although I had been long acquainted with the physiological facts, it was not till within the last ten or twelve years that I saw the whole of their bearing on the practical department of our profession, and consequently still later before I had that direct practical proof of the accuracy of my inferences which I con-

sidered necessary to entitle me to lay the results before the public. In the present treatise I have been enabled to enter on them much more fully than in that just mentioned, both from additional experience and reflection, and because the object of the present publication is wholly of a practical nature.

I have attempted in it to bring the subject into one view, and to express myself in the simplest language I can, that, for reasons fully stated in this preface, the non-professional reader may comprehend whatever is necessary to be attended to, in order to understand and prevent the usual consequences of uniform and long-continued derangement of the digestive process, which is the source of all our powers, and on the healthy state of which both our present comfort and usefulness, and, eventually, the continuance of our lives, depend; and that, as I have just observed, in a way that has not hitherto been understood, and which has prevented our making the necessary distinctions between the effects produced by the temporary and permanent derangement of the digestive process, that is, between a temporary disease unattended by danger, and the treatment of which is well and generally understood in our profession, and one that strikes at the very source of all our powers, and the successful treatment of which is at present unknown; for my efforts to make the latter generally known have been counteracted in the way I shall explain in this preface,—the cause, indeed, of the present publication. It is a state of disease which, if the patient is not cut off by the supervention of some more rapid disease, to which it renders us more liable than in health, necessarily, we shall find, ends, if not removed in its earlier

stages, in a certainly, and at length a rapidly fatal termination, — and thus many thousands of lives are yearly sacrificed even in this country, in which, I believe, we are entitled to say the medical profession is better understood than in any other.

It is observed in the introduction to the third part of the fourth edition of my Inquiry into the Laws of the Vital Functions, that the defects in the practical department of our profession which the Investigation above referred to tends to supply, are,

"1. Our not being sufficiently aware, from a defective knowledge of the relation which the various functions bear to each other, of the tendencies of continued states of chronic disease; in consequence of which, in a numerous class of such diseases, the curative stages are often allowed to pass disregarded.

"2. The attention in many acute diseases, from the same cause, being often confined to the more evident train of symptoms, where the derangement has had its origin in a more obscure affection, without the removal of which that of the more prominent disease is impossible; and,

"3. From our not having been aware either of the nature or most important functions of the nervous influence, or of the seat of the organs which alone supply that influence, and on which those functions immediately depend; we have neither been aware of many of the symptoms which indicate its failure, nor in possession of the most effectual means of remedying its defects."

A little reflection at once points out that a mistake with respect to the seat of the organs of any important vital function, or set of functions, the nature of the powers which maintain them, the laws they obey, and the relations they bear to each other, must ne-

cessarily tend to obscure our knowledge both of the nature of their diseases and the effects of the remedies which relieve them.

If any person acquainted with the present state of our profession does me the honour to peruse this Treatise, I think he will excuse my saying that it will afford aid where aid is most wanted.

Amidst the various improvements which have taken place in the state of the medical profession, our knowledge of the nervous system has remained nearly stationary. The nervous influence has been regarded as of a nature so obscure, that an attempt to refer it to any more general principle would necessarily be vain ; and we have in little or no degree, for several centuries, advanced either in our knowledge of the power on which its phenomena depend, or the modifications of that power by which each of its various functions is immediately effected; no serious attempt, as far as I know, having been made to determine either of these points. Nor have the limits of its functions been accurately ascertained, no correct line of distinction having been drawn between the nervous and sensorial functions, although it is evident to the most careless observer that these functions are of the most dissimilar nature ; hence a difficulty confessed by M. le Gallois, to which I shall presently refer ; nor has even the seat of the organs of the nervous power, properly so called, been ascertained.

The nerves, we shall find, convey three different species of influences of the most dissimilar properties ; so much so, that there is not even one property in common to the three species, each being conveyed by

its own class of nerves: yet we still speak as if there were but one species conveyed by all nerves; nay, we shall find that there is one of those classes of nerves, although so called from their resemblance to other nerves, that belongs not to the nervous system, properly so called, which conveys an influence and contributes to functions of a wholly different nature from those which belong to that system. In consequence of our ignorance of the source from which the nervous system derives its power, we have not only failed in drawing a correct line of distinction between the functions of the nervous and sensorial powers, but also between the organs of those powers.

We shall find, indeed, that we have not only had no correct knowledge of the functions of the different parts of the nervous system, but, from too hasty inferences, even ascribed to one set of organs, functions of the most important nature, which belong wholly to another.

Is it possible that such defects of knowledge, and necessarily consequent confusion respecting organs which we shall find supply the leading power in all those functions which maintain the due structure of our frame, can exist without interfering with the regulation of the most effectual means for restoring them, when, from the various causes of injury to which their organs, like all others, are necessarily more or less exposed, they had deviated from a state of health, without being deprived of some part of the means by which the restoration of this state may be effected? How far it has had this effect will appear from the statements I am about to make in the first part of the following treatise, from which we shall find that in many cases the correction of the errors here referred to renders

recovery both more speedy and more certain ; and in some cases of frequent occurrence, and of the most formidable nature, influences our treatment of disease, even to the extent of changing the almost certain fatality of the case into a similar certainty of recovery. It is the conviction of the accuracy of these statements that has induced me to offer the following volume to the public ; nor could I leave the profession with an easy mind, without having done all I could to make them known. It remains with the reader, when the facts are laid before him, to judge how far they sanction such a feeling.

Many of the physiological inconsistencies referred to in the preceding pages were for a short time supposed to have been removed by the experimental inquiry of M. le Gallois, entitled "Expériences sur le Principe de la Vie, notamment sur celui de Movement du Cœur, et sur le Siége de ce Principe;" respecting which the class of Physical and Mathematical Sciences of the Institute of France received from their committee, consisting of the celebrated M. de Humboldt, M. Hallé, and M. Percy, a very long report, which is given in the first part of my Inquiry into the Laws of the Vital Functions, after all the experiments had been repeated in their presence, and which concludes in the following manner : —

"In a word, it appears to us that we may say of the authors who have had some views on the subjects of which M. le Gallois treats, what M. Laplace has said with so much justice on a similar occasion ; namely, one may there meet with some truths, but they are almost always mixed up with so many errors that their discovery belongs only to him who, separating

them from this mixture, succeeds by calculation or observation in effectually establishing them.

"The opinion of your Committee is, that the work of M. le Gallois is one of the most excellent, and certainly the most important, which has appeared in physiology since the learned experiments of Haller; that this work will make an epoch in that science over which it must spread a new light; that its author, so modest, so laborious, so meritorious, deserves that the Class bestow on him its especial commendation, and all the encouragement which it can give. They cannot help adding, that the memoir of which they have given an account is worthy to occupy a distinguished place in the Transactions of learned correspondents, if the publicity of the important discoveries contained in it may be deferred to the time, perhaps distant, of the publication of those transactions.

(Signed) "De Humboldt.
"Halle.
"Percy.

"The Class approve their Report, and adopt its conclusions.

"It moreover decrees, that the Report shall be printed in the History of the Class, and that the Committee of the Class shall make arrangements with M. le Gallois for defraying the expenses which have been occasioned by his experiments, and enabling him to continue them.

"Certified to be conformable to the original.

"G. Cuvier, *Perpetual Secretary.*"

Under such patronage, it is not surprising that the conclusions at which M. le Gallois had arrived were

generally admitted both in this country and the Continent; and it must appear an extraordinary assertion that, as far as I am capable of judging, the experiments of M. le Gallois do not warrant any one of the general inferences stated by the committee as their results. It is, however, I believe, since the public repetition of my experiments, both in London and Paris, confirming the results I had obtained — made in the latter city on a far more extensive scale than has been attempted in this country, — generally admitted that such is the case. An account of all the experiments by which this was proved will be found in the Phil. Transactions of London, between the beginning of the year 1815 and the end of 1836, and in the second part of the fourth edition of my Inquiry into the Laws of the Vital Functions, published in 1839. See the notes in the 21st page of this preface.

The Report of the Committee of the Institute of France, given in the first part of my Inquiry into the Laws of the Vital Functions, as a review of the state of our knowledge of the subject at the time M. le Gallois began his experiments, appears to be accurate, well arranged, and sufficiently comprehensive. As an account of his experiments and opinions, nothing, as far as I can judge, can be more clear and correct; but as an estimate of the merits of his work, it does not deserve the same praise. It overlooks defects both in the experiments and reasonings of M. le Gallois, which invalidate all his most important conclusions, and leave him the discoverer of certain unconnected, though most valuable facts, instead of the author of a new system, founded, as the report alleges, on a basis never to be shaken.

If the conclusions at which M. le Gallois arrived be not legitimate inferences from his experiments, the explanations of the long-contested points founded on these inferences, respecting the action of the heart and vessels, the nature and origin of their power, the relation which they bear to the various organs of the nervous system, properly so called, and the relations of both the nervous and muscular systems to the sensorial system, founded on them, are necessarily inadmissible.

With regard to the last, the most complicated of these divisions of the subject, namely, the relation of the muscular and nervous systems to the sensorial system, the inadequacy in one respect of M. le Gallois's inferences to explain its phenomena, as appears from what I am about to say in this preface, he has himself candidly acknowledged.

In some other instances, the means of refuting his inferences were even then at hand, without his appearing sensible of their being so. He observes, for example, in the commencement of his work, "Ce que j'y ai dit du cœur pouvant s'appliquer aux autres organes des fonctions involontaires, la question peut être considérée plus généralement comme la determination du siége du principe qui préside à cet ordre de fonctions." Yet he shows that decapitation does not influence the function of the heart, while even then it was known that the division of the eighth pair of nerves in the neck more or less injures that both of the lungs and stomach.

Thus we must wholly dissent from the following opinion of the committee, that "the results of M. le Gallois's experiments resolve with ease all the difficulties which have arisen from the days of Haller

respecting the causes of the movements of the heart." These experiments, indeed, by ascertaining some facts of great importance, while others immediately connected with them escaped M. le Gallois's attention, have left the subject in greater confusion than he found it. Instead of removing the difficulties which formerly existed, the valuable additions he has made to our knowledge have shown us others.

The heart's being subject to the influence of the passions, for example, although independent of the brain, on which so much has been written, is not more difficult of explanation than that the destruction of the same part of the spinal marrow should, according to the way in which it is effected, either instantly destroy the power of the heart and vessels, or not in the least influence it.

I have had occasion, in the first part of my Inquiry into the Laws of the Vital Functions, to point out that M. le Gallois's explanation of this difficulty is not a legitimate inference from his experiments; and to relate some experiments so simple that it is impossible to be deceived in their results, which directly refute it.

Similar observations apply to the other leading positions of M. le Gallois, all of which are fully considered in the first part of my Inquiry.

If, for example, the power of the heart and vessels immediately depend on the spinal marrow, which at first view seems a necessary inference from the experiments of M. le Gallois, why is their action wholly uninfluenced, as appears from experiments detailed in the second part of my Inquiry into the Laws of the Vital Functions, by the total removal of that organ? Why have fœtuses been born alive where no spinal

marrow had ever existed ? * why, if (as M. le Gallois maintains, and it is generally admitted) the various organs of involuntary motion bear the same relation to the nervous system, is the function of the heart and vessels not directly influenced either by decapitation or removal of the spinal marrow, while the secreting power throughout the system is impaired or destroyed according to the degree in which the powers of either the brain or spinal marrow are impaired ? and why do the division of the eighth pair of nerves in the neck, and the separation of the divided ends, wholly destroy the function of both the stomach and lungs, while they do not at all directly influence the heart or vessels ?

Why do the motions of respiration cease on the destruction of a certain part of the brain (the medulla oblongata), since the nerves of the muscles employed in respiration arise from the spinal marrow, which

* We have reason to believe from many facts that the fœtus receives the vital nervous influence (which we shall find in many respects essentially differs from the nervous influence of the sensitive system, and proceeds from a very different source) from the mother ; else how is it possible that the development of any of its organs could take place ? To enter fully into this disquisition would not be consistent with the nature of the present publication. When the subject is duly considered, it will appear that the origin of the two sets of organs, the vital and sensitive, must, like their functions, be wholly different. The origin of the one set must exist before the parts themselves are formed, because their functions are those of forming and maintaining all parts of our frame. Their formation must depend on an influence supplied by similar parts, already perfected ; and we can see no source for such supply but the vital organs of the mother : while, with respect to the sensitive organs, there is no necessity for the existence of their powers till the organs themselves are fitted for their functions.

M. le Gallois has proved to be capable of exciting the muscles independently of the brain? He considers this subject at length in the thirty-fifth and following pages of his treatise, and admits that he can give no explanation of it, calling it "one of the great mysteries of the nervous power, the discovery of which will throw the strongest light on the mechanism of the functions of that wonderful power."

All these, and other inconsistencies, for which I refer to the first part of my Inquiry, it is evident, as well as those which existed previously to the discoveries of M. le Gallois, must be reconciled, before we can possess any correct views of the laws of our frame. The doctrines which cannot reconcile them must be erroneous, and we shall find, as might be expected, particularly considering the nature of the points to which they relate, lead to important errors in the practical department of medicine — far more important than I was for many years aware of, after the chief physiological facts had been ascertained; for the subject being very complicated, it was long, even with the phenomena constantly employing my attention, before I saw their full extent; so that it is only in the last, the fourth edition of my Inquiry into the Laws of the Vital Functions, published in 1839, that even an attempt is made fully to state them; and the present publication enters much more fully into this part of the subject than is attempted even in that edition, the principal objects of this volume being to explain to the well-educated public the manner in which our physiological errors have produced their fatal effects in the practical department of medicine, and the means by which they may be prevented, that those practitioners who at present

possess the public confidence may be compelled to turn their attention to them; for a little consideration will point out how difficult it must be for those who have been long engaged in the practice of medicine in any respect to change the principles on which they have practised; they naturally shrink from the trouble which attends such an attempt; and how little encouragement medical practitioners have to attend to new suggestions in their profession, which experience has told us are so often fallacious.

On the other hand, I am impressed with the belief, which I think will be the belief of those who duly consider the following volume, that when the necessary inferences from the facts it contains regulate the treatment of disease, thousands will annually be saved who at present fall a sacrifice; I say, as I am impressed with this belief, I cannot, as I have above observed, leave the profession with an easy mind, without doing what I can to make them generally and speedily known.

There are but two means by which this can be done,—either by inducing those practitioners who at present possess the confidence of the public to adopt them; or by laying the facts before the public in so simple a form that the public themselves will see the whole of their bearings, and from this knowledge be led to insist on their physicians affording them the attention which their importance demands.

The first of those means I have already attempted, and found it wholly impracticable. Those who do not belong to the medical profession, as I have just observed, cannot easily understand the difficulty of changing the principles on which a physician has long

practised, and all changes founded on the correction of physiological errors must be of this nature.

It is like again going to school. He neither has experience of the necessary modes of examining the patient, nor of the inferences to be made from what is perceived in an examination which is new to him — a knowledge which can but in a very imperfect degree be conveyed by words, as I have found; for I have attempted by repeated publications, correspondence, consultations, and whatever other means presented themselves, to supply the want of personal experience, but in vain. It is hardly to be expected that those who already have their time fully occupied will put themselves to the trouble of supplying this experience; and I have not in any instance, to the necessary extent, been successful in my attempts to induce others fully to adopt the plans of treatment which necessarily result from the correction of the physiological errors above referred to; although many of the practitioners of London and its neighbourhood, having seen the effects of what I consider the improved treatment, have more or less adopted it. But it is in some respects complicated, and none, as far as I know, have employed it in the extent necessary to its most successful results, and in general no attempt of the kind has been made; not even to the extent necessary to distinguish the cases to which it is adapted. The remaining means, therefore, I adopt; that is, addressing the well-educated public on leaving the profession, when I can no longer be accused of acting from interested motives, unless the desire to make the labours of a lifetime as advantageous to the public as I can be regarded as such.

I shall here quote the following passage from the preface to the fourth edition of my Inquiry into the Laws of the Vital Functions.

" Even the least reflecting of our profession will admit, the better we understand the laws of our frame, the more successful will be the treatment of its diseases.

" When a new medicine is proved to be capable of relieving a disease which has hitherto defied our means, the value of the fact is at once apparent; and the trouble of acquiring a knowledge of it, and applying that knowledge, very trifling. It is, therefore, generally and thankfully adopted.

" But although it will be admitted by all that the correction of an old or the adoption of a more successful principle of treatment may be more valuable than the discovery of any single remedy, it can never be received or applied with the same readiness.

" In a profession which teems with so many proposed improvements, not one in a hundred of which proves of any value, it is necessarily long before any suggestion, more complicated than a simple matter of fact, finds its due level; and however easy the knowledge and application of a new remedy, the adoption of a new principle of treatment is in all instances more or less difficult and laborious to those who have long reasoned on different principles.

" Many additions have been made to the physiological department of my experimental Inquiry since the publication of the third edition, which the Royal Society have done me the honour to publish in eight papers during that interval.

" In the present edition, these additions are incorporated with those parts of the Inquiry to which they

relate; and the greater and most important part of the practical department is for the first time offered to the public; for at the time of the publication of the last, the third edition, my views not being sufficiently matured respecting the more complicated part of the subject, I abstained from entering on it.

"The chief object of the former editions of this Inquiry was to remove the inconsistencies which prevail in our doctrines respecting the general laws of the Vital Functions. The facts by which this has been effected have now, I believe, been generally admitted; in consequence of some of the most important experiments on which they are founded having been publicly repeated with the same results both in London* and Paris.†

"The chief object of the present edition is the application of these results to improve the practical department of our profession, by laying before the reader, at one view, the observations which have gradually accumulated during a practice of long continuance, in confirmation of the advantages thence arising; and this I do with the more confidence, that I can now refer to the experience of many of my professional brethren in support of my own observations."

It is in the present Treatise requisite to explain to the profession, as well as to the general reader, the

* The Philosophical Transactions of London, and the Journals of the Royal Institution, both for the year 1822.

† "De l'Influence du Système Nerveux sur la Digestion Stomacale; par MM. Breschet, D.M.P., Chef de Travaux Anatomiques de la Faculté de Médecine de Paris, etc.; H. Milne-Edwards, D.M.P.; et Vavasseur, D.M.P. (Mémoire lu à la Société Philomatique, le 2d Août, 1823).—Extrait des *Archives Générales de Médecine*, Août, 1823."

principles on which I propose the alterations of treatment which appear to me necessary in certain cases of our most common and fatal diseases. Were I, for instance, without such an explanation, merely to assert that among the causes of the common hereditary pulmonary consumption of this country a diseased state of the brain and spinal marrow is so essential a one, that all cases of hereditary consumption may be prevented by its removal, — which we shall find, with one and that a rare exception, can always be effected, if the proper treatment be not too long deferred,—it would be regarded, in the present state of our profession, as a position equally inconsistent with the phenomena of the disease and the laws of our frame. It would not even be understood by the members of our profession on what such a statement could be founded. From the facts laid before the reader in the following Treatise, however, I confidently expect that it will be admitted by all who are capable of judging of what I shall have occasion to say of the nature of this disease, and acquainted with the laws, which I believe are, since the public repetitions of my experiments above referred to, generally admitted to be the laws of our frame, that such is the case. And what makes this knowledge of importance, and is consequently one of the chief motives of the present publication, is, that it is by it alone that the fatality of pulmonary consumption has been prevented; for after resisting all the other means which have been tried, by those thus suggested this disease has been wholly banished from some of the most consumptive families of this country; *in every instance*, as far as I know, in which the proper means have been employed from the commencement of the disease.

It would swell this volume to too great a size, were I to enter into detail on the treatment of each particular disease belonging to the principal class of diseases I am about to consider. It will be sufficient to point out the nature and principles of treatment in this class, and to select the most important of the diseases arranged under it for particular consideration.

The one I have chosen for this purpose, which, both from its great frequency and fatality, and from its occurring chiefly at the most important and interesting period of life, may be regarded as the chief of this class, is the disease I have just referred to, — pulmonary consumption; and there is also this additional reason for the choice I have made, that the advantage of the plan of treatment here referred to is more easily rendered evident to the non-professional reader, than in any other of the same class of diseases. And having entered fully into the treatment of this disease, I shall point out how far the same observations apply to all other diseases of the same origin; namely, certain species of apoplexy, palsy, and indeed, occasionally, to certain diseased states of all vital organs. To this head we shall find many of those diseases belong to which I have above referred, which, after years of obstinate suffering, prove fatal without the nature of the case, in consequence of our present physiological errors, having been understood; and particularly our not having been aware of the change which has for a long time been going on, consisting in a gradually increasing debility of the brain and spinal marrow; the influence of every part of which organs is, we shall find, immediately necessary to the functions of all,

even the most minute vital organs. Under such circumstances, the vital organ most inclined to disease failing in its functions as soon as the influence, depending on the brain and spinal marrow, fails to a certain degree, and the functional disease, in consequence of the debility of the central organs, on which the due organization of every part of our frame we shall find immediately depends, running rapidly into disease of structure, the fatal termination necessarily ensues.

I have already had occasion to observe, that I was not till within the last few years fully aware of the extent to which the results here referred to apply to the practical department of the medical profession; and it is only in the last part of the fourth edition of my Inquiry, published in 1839, that I for the first time attempted to point out to what extent they do so, and in the present publication facts are stated which still to a considerable degree increase that extent. The Inquiry just referred to is not likely to be in the hands of those most immediately interested; nor, if it were, would it be well understood by them. I have therefore felt myself called upon, for reasons stated in this preface, on leaving the profession, to publish the following Treatise, within the comprehension of every well-educated person, in which I have selected from the Inquiry those parts alone which relate to the diseases in question, expressing all that relates to them in the plainest language I can. It will appear that, with a few exceptions, it is always possible to avert very common forms of a numerous class of diseases, which, if they are allowed to arrive at a certain stage, do not, according to our present plans of treatment, admit of cure.

The great object in the treatment of disease, ex-

cept where we merely practise on the principle of employing the means which have formerly been useful in similar cases, is to trace the changes on which the disease depends. This is the foundation of all rational, in contradistinction to mere empirical treatment, which must always more or less rest on confined, and therefore often erroneous grounds.

The only treatment of disease on which we can rest with confidence, because the only one in which we can confidently foresee the effect of our means, is that founded on correct views of the nature and functions of our frame. In such cases, if our observation and reasoning be correct, the effect of the treatment is always easily foreseen. With respect to empirical treatment, except in the simplest cases, the result is always more or less doubtful; because the least variation in the nature of the case from those cases in which the practice has been successful, even so slight as not to attract the attention of the practitioner, where the nature of the case is not understood, may occasion an essential change in the effects of our remedies. Such are the varieties both of disease and constitution, that we can never rely on the results of mere empirical practice.

Many of the statements on which the treatment recommended in the following volume is founded were published as early as 1817, in the first edition of my Inquiry into the Laws of the Vital Functions; and their accuracy, we have seen, has since been confirmed by others, and by experiments made on a much more extensive scale.

All diseases appear both in the original and symptomatic form, and the reader will easily understand

why it is necessary to distinguish these forms; because in the first we have only to consider one disease; in the other, if the proper treatment of the disease in which that which is generally the more prominent originates be not at the same time kept in view, we labour in vain in attempting to remove the secondary disease.

Some vital organs possess so little sensibility, that our attention is chiefly called to their diseases by the effect they have on more sensitive parts, and in many instances in which we have been misled it has arisen from this cause. It thus becomes necessary, in a great proportion of cases, to be acquainted with the nature and functions of the parts affected, and their relation to other organs, and to be in possession of an accurate detail of the symptoms from the time the patient first began to complain, before the proper treatment can be ascertained; and to this, more than to any other cause, we may ascribe the injury done by the physiological errors which at present prevail.

The subject, however, as the reader must have already observed, is necessarily rather complicated; and it requires some attention to perceive the manner in which the various facts bear on each other, even when they are all the necessary results of the most familiar laws of our frame.

Few have been engaged in so many physiological controversies as have fallen to my share; and I feel gratified in being able, without hesitation, to call on all my opponents, whether in these kingdoms or other countries, in such discussions, to point out a single instance in which my statements have been proved to be erroneous; and I hope it will be be-

lieved that where the lives of my patients were concerned, my observations were made at least with the same care and anxiety with which my physiological experiments were conducted. And whereas my experiments were only at most repeated three or four times, my practical inferences have been more or less the subject of my daily observation, many of them for more than five-and-twenty years; and there is this additional argument in favour of the accuracy of the latter, that the practice has spread faster among those who have witnessed its effects, when properly conducted, than there was reason to expect from its novelty and the usual fate of proposed changes in the principles of treatment in our profession, which all changes in consequence of the correction of physiological errors must be.

In the alterative part of the treatment of the diseases I am about to consider, much use is made of very minute doses of mercury; the largest dose usually employed being the twentieth part of a grain of calomel, and, under certain circumstances, so small a dose as the fiftieth or the hundredth part of a grain; and even this last dose, taken every eight hours, I have repeatedly seen affect the mouth in less than a week. When this in any degree supervenes, the use of the medicine, in the cases above referred to, is always discontinued till it disappears. A course of such doses has none of the bad effects of a course of mercury; it neither debilitates the vital functions, nor exposes the patient to the risk of taking cold, any of these quantities being too small to maintain an open state of the surface. If the rules laid down in the practical part of the Treatise be attended to, they never

dispose to any of the bad consequences of a course of mercury, and may be continued for whatever length of time without producing any unfavourable effect, except that of becoming useless by losing, from the force of habit, their own power; but for the occurrence of this effect many years I have found are required. All these circumstances have been ascertained by an extensive experience of more than five-and-twenty years. In the cases I am about to treat of, the remedy is rendered not only effective, but harmless, which a long-continued course of mercury can never be in our usual mode of giving it. We are often obliged to run the risk of it, however, in those cases in which a salivation of some continuance affords the only chance of saving life.

There are two modes of giving mercury, from which I have never seen any lasting bad effects of any kind, and few have seen it in its various forms so extensively employed; I mean in what I call the minute doses, those not exceeding the power of a twentieth part of a grain of calomel, the treatment being conducted in the way I shall explain, and the mere passage of ordinary doses through the alimentary canal, none being retained: and these are the only modes of giving mercury necessary in the diseases of which I am about to treat in this volume. All the bad effects of mercury, which are many (for how could we hope for so powerful a remedy, if not cautiously employed, being free from risk?) arise from too much having been received into the system. In the diseases I am about to consider in the following volume, it is not merely that the minute doses are safe, but it will be easy to demonstrate from the laws of our frame, as I trust the reader will acknowledge when he has perused this volume, that the minute

doses of mercury are the only means by which, in certain cases, health can be restored, and thus, life eventually saved. In them we shall find that the central organs of our system, the brain and spinal marrow, on which all the immediate functions of life depend, have been debilitated; and mercury, if allowed to enter the system in the usual doses, never fails, however it may on the whole relieve for the time, to add to their debility, and thus, in most cases, in the way I shall explain, to hasten the fatal termination.

There are few cases in this country in which it will not be found that mercury in some form is among the means of treatment. I cannot recollect any instance of serious disease, to which I have been called in consultation, in which I did not find that such had been the case. Would it not be absurd to suppose that this universal employment of it in a country in which, as I have already had occasion to observe, it is not assuming too much to say that the practice of medicine is better understood than in perhaps any other, could proceed from any other cause than our finding from it beneficial effects which could not otherwise be obtained?

The cause of the prejudice which prevails against mercury is, that we have been working with its debilitating doses alone; for every thing which makes an impression on our frame, whether affecting mind or body, acts either as an exciting or debilitating cause, according to the quantity employed. To a certain degree, and when applied in a certain quantity, all agents capable of influencing either mind or body more or less, however little, excite; and will more or less act as a tonic, if properly applied with that view. I have been at much pains to ascertain the

tonic range of mercury, and have found that it is a dose not exceeding in power the twentieth part of a grain of calomel; but this, as might be expected, to a certain degree varies in different constitutions, and particularly according as the action of the excretory organs is more or less vigorous. The skin is the organ by which mercury, after it has entered the circulating system, is most rapidly carried off; for it is altogether an error to suppose that any active preparation of mercury ever accumulates in the constitution. The chemical powers of the constitution always reduce it to the metallic state; and if it remains at all, it remains in this state in the form of globules in what is called the cellular substance, in which it is perfectly innocent. It may be drunk in this state without injury, in the quantity of a pound weight or more, and has thus been very absurdly employed in the case of obstructed bowels without any injury.

The following Treatise is divided into two parts. In the first I shall explain the nature of the physiological errors which have prevailed in our profession, and the manner in which they have produced the fatal effects I have ascribed to them, and also the general nature of the diseases which are the subject of the present volume; and in the second I shall lay before the reader the means which have proved most successful in the prevention and cure of those diseases.

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CHAPTER I.

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* The last two Numbers should have been XI. and XII.

A

TREATISE ON INDIGESTION,

&c.

PART I.

ON THE POWERS OF THE MORE PERFECT ANIMALS, AND THE RELATIONS THEY BEAR TO EACH OTHER AND TO THE POWERS OF THE INANIMATE WORLD.*

It appears, from what has been said in the preface, that at the time the investigation in which I have been so long engaged, and on which the original parts of the following work are founded, was begun,

* My reasons for addressing the following Treatise to the non-professional as well as the professional reader are explained in the preface. But, although it is necessary for those who wish fully to enter into the subject, that they should be acquainted with the first part of this Treatise, in which I have used the plainest language I can, it is not necessary, in order to apply the rules of treatment, that the non-professional reader should be master of that part; which, from the nature of the subject, is necessarily rather complicated, unless he wishes, unaided by medical assistance, himself to attempt the treatment; which, for many reasons, it is better not to do, where such aid can be procured; because, with all that can be communicated in such a Treatise as the present, it requires some personal experience to enable the practitioner to feel himself at home in the detail of medical treatment: but I hope that those of my medical brethren, who do me the honour to peruse this work, will admit that their patients are entitled to request them to make themselves acquainted with the facts stated in it, which at present are not elsewhere to be found.

B

the general laws of the various functions of life were involved in contradictions which demonstrated essential imperfections in our knowledge of them. This, it will readily be admitted, could not be the case without more or less leading to errors in the treatment of their diseased states; and, as I have there observed, when time and opportunities afforded means of judging of the nature and extent of the practical errors thence resulting, they proved of greater importance than I was aware of for many years after the correction of the physiological errors had been generally admitted.

As has been explained in the preface, the only choice left to me is, either letting the results of the labour of a lifetime, on subjects of no common interest, be lost to the public at large, till a new race of medical men possess their confidence, (for, since the public proofs of their accuracy, these results already begin to be taught in the schools *), or addressing such a work as the present to the public themselves.

Of the present race, it is only those who in consultation with me have witnessed the treatment founded on the facts here referred to, who can speak to its effects; even the mode of regulating the most essential parts of it being still in a great degree unknown to others, although I have done all I could to make them generally known.

In order to regulate the treatment, it requires, as observed in the preface, a personal experience, both in the examination of the patient, and the proper judg-

* See the accounts of the public repetition of my experiments, both in London and Paris, in the years 1822 and 1823, referred to in the preface.

ment to be formed from what is perceived by the hand of the examiner: and till some degree of this experience is acquired, it is impossible to avoid error, however accurate the knowledge of all that can be conveyed by language may be; an experience only to be acquired by attention to the means pointed out in the practical part of this volume.

As a chief object of the present publication is, for reasons stated in the preface, to make the well-educated public acquainted with the laws that regulate the diseases here referred to, which, as appears from what is there said, in the present state of the profession is equally necessary both for the prevention and cure of those diseases, some of which are among the most frequent, deep-seated, and fatal we are subject to; — as such, I say, is my object, and I have no other means left of accomplishing it, it is necessary, in the plainest language I can, to lay before the reader those physiological misconceptions which have led to the fatal errors to which I refer, and the means by which they have been corrected. The accuracy of the experiments on which their correction is founded, it appears from what is said in the preface, has been publicly confirmed by some of the first physiologists both of this country and the continent; and that under the most unfavourable circumstances, prepossessed, as they necessarily were, in favour of the prevalent opinions.

That the subject may be rendered as simple as possible, I shall, in the first place, give a general view of the laws of our frame, pointing out those ascertained by the investigation on which the practical part of this volume is founded, and entering no farther on this part of the subject than is necessary to

give the reader a clear comprehension of the nature of the diseases in question.

In order to effect this in the best way I can, it is necessary for me to enter much more fully into the results of the investigation on which all I am about to say is more or less founded, than I have done in any other publication; and therefore, while, for reasons stated in the preface, I address this treatise to the public, I also address it at the same time to the professional reader, as by far the fullest account which has appeared of those results, some of them never having been previously laid before the public.

All the functions of the more perfect animal may be divided into two systems, the influence of both of which, we shall find, pervades every part, even the most inactive and insensible, of our frame: the vital system, by means of which life is maintained; and the sensitive system, by means of which we are connected with the world which surrounds us, and, consequently, on which all our enjoyments and sufferings depend.

Now, distinct as the objects of these systems are, from the manner in which the functions of each influence those of the other, the actual existence of each depends on that of the other. We shall find that, in the more perfect animal, the existence of the vital depends as much, though not so directly, on the sensitive, as that of the sensitive on the vital system.

It is this part of the subject, as appears from what is said in the preface, on which M. Le Gallois confesses his investigations throw no light. Had he seen with equal clearness the other deficiencies of his system, he would have done greater service to science by the important additions he has made to our know-

ledge, because he would not have misled by his ingenuity, where he found the more simple and evident inferences from the facts he had correctly ascertained could not serve the purpose he had in view.

He did not sufficiently perceive that the very complicated nature of the subject of his experiments, and the relations which all parts of it, more or less, bear to each other, made it necessary to reject every inference, however it might seem a necessary consequence from the particular facts on which it appeared to be founded, which was in any way inconsistent with correct inferences from other well-ascertained facts, relating to other parts of the animal economy.

Can any thing be more evident, for example, than that the destruction of the powers of circulation, being the *immediate* consequence of the removal of a certain part of the brain, must depend on some principle altogether distinct from their being wholly dependent on the spinal marrow; the powers of this organ, although in some respects subjected to the brain, having, as Le Gallois himself admits, and as has been proved to be the case, no direct dependence on those of the brain?

Each of the two systems, the vital and sensitive, into which the functions of the more perfect animal arrange themselves, is regulated by a leading power, which is the chief agent in all their functions, and to which all their other powers are subservient; and on the laws of these systems, and the various relations they bear to each other, the whole phenomena of the more perfect animal depend.

I propose, here, to make the reader acquainted with such of those laws and relations as operate in the production, and consequently demand attention in

the prevention and cure, of the diseases I am about to consider.

In the more perfect animal *, as appears from facts which were either generally admitted previously, or are now admitted, both in this country and on the continents with which we are in immediate intercourse, as ascertained by the long-continued investigation referred to in the preface †, there are four distinct sources of power, of which no one is immediately dependent on any of the others; the sensorial and nervous powers properly so called, the muscular power, and the powers of the living blood.‡

Thus, although each of these four powers has an existence not immediately depending on any of the others, the muscular power and the powers of the living blood are capable of being more or less directly influenced both by the nervous and sensorial powers: by the nervous powers always directly, that is, not through the intervention of other powers; and by the sensorial powers, either directly, that is, through the nerves alone, or indirectly through the nervous powers properly so called, and with respect

* Many of the observations I shall have occasion to make, do not apply to the animals usually termed the less perfect.

† See my papers distributed through the Philosophical Transactions of London, from the beginning of the year 1815 to the end of 1836, and the fourth edition of my Inquiry into the Laws of the Vital Functions, published in 1839, in which the whole of the statements here referred to, though not the whole of the necessary inferences from them, will be found.

‡ See my paper On the Vital Powers of the more perfect Animal, in the second part of the Philosophical Transactions of London for 1836, and the second part of the fourth edition of my Inquiry into the Laws of the Vital Functions.

to the muscular fibre, not only as far as relates to its excitement, but also as far as relates to the direct privation of power, that is, independently of any previous excitement, and that, even to the extent of the total privation of all power; and through the same classes of nerves, namely, those belonging to the nervous system properly so called, and those which, we shall find, belong to the sensorial system, these powers are subjected to each other, without the intervention of any other powers.* And, on the other hand, the changes which originate in the muscular fibre as well as other sensitive parts, and in the living blood, through those two sets of nerves, (neither of which can originate any change, and therefore may be regarded as parts of the organs to which they belong,) influence both the nervous and sensorial powers; the nervous powers always directly, that is, through their nerves alone, which communicate any change effected by these powers, but cannot themselves originate any change; the sensorial powers, either directly through the nerves of the sensorial and those of the nervous systems, or, as I shall presently have occasion more fully to point out, indirectly through the intervention of the nervous powers themselves.

Thus it is that an extreme impression made on the organs of the sensorial powers may, either directly or indirectly, destroy all the powers of the more perfect animal; and that, if the cause be ex-

* The nervous power properly so called being capable of producing such changes in our organs as immediately influence the sensitive nerves, and the sensorial powers being capable of producing such changes in our organs as immediately influence the nerves of the nervous power properly so called.

treme, instantaneously, as we see happens in sudden and extreme mental affections: and, on the other hand, an extreme impression made on the organs of the nervous power itself may destroy all the vital powers, and, consequently, indirectly the sensorial power also; and that instantly, when the cause is extreme, as we see happens in the most severe cases of nervous apoplexy, and eventually, in all fatal cases of this disease.

Thus it appears, that, although the sensorial power exercises no direct influence on the organs of any vital power except the nervous properly so called, it may, through it, influence the muscular power and the powers of the living blood, more or less rapidly according to the power of the cause applied, and that, even to the immediate and total destruction of all their powers.

The nervous power thus enacts a very complicated set of functions. It is not only the most immediate and efficient power in the vital system, and that by which all the other powers of this system, properly so called, are influenced, and is therefore correctly denominated its leading power; but, as we have just seen, it performs the functions of the only medium by which the other powers of the living animal indirectly influence, or are indirectly influenced by, the sensorial powers.

Thus it is that an injury done to any vital organ may either, if severe, rapidly, or, if less severe but of a permanent nature, by degrees, undermine the whole powers of the system; and thus we shall find that certain chronic affections, which in their early stages give little trouble, and consequently command but little attention, are often eventually the means of destroying all our powers.

The nervous power, moreover, performs other functions of the most important nature. It constitutes an essential part of the medium through which the sensorial powers are both influenced by the agents of the external world, and through which those powers influence them. Many circumstances relating to this part of the subject it will be necessary, in preparation for the practical part of the present Treatise, here to consider at some length.

I HAVE had occasion to observe, that as the sensorial power properly so called is the leading power in the sensitive, the nervous power properly so called is the leading power in the vital system; the muscular power and the powers of the living blood being under command of, and employed by, the leading power of each system; directly, that is, through its nerves alone, in the vital system, and indirectly in the sensitive system; its leading power directly influencing no other but the nervous power*, by which both the muscular power and the powers of the living blood are directly influenced. By keeping these statements in view, and by what will be said of the nature of the leading power in the vital system, we shall find that we are enabled to draw a well-defined line between the sensorial and vital functions; the want of which, we have seen, was one of the chief causes of the errors of M. Le Gallois, and has necessarily essentially influenced the practical department of our profession.

* That is, no other through the nerves alone, which, we have just seen, can convey the impressions they receive, but can themselves originate no change, there being no proof of the common opinion that the connection of nerves in their progress influences the phenomena of the system to which they belong.

Such are the powers of the more perfect living animal, and the relations they bear to each other, supported either by facts long admitted by all, or by the experiments on which this Treatise is in a great degree founded, the most important results of which have been confirmed both in this country and on the Continent; and we shall find certain modifications of many formidable diseases yield to means suggested by the results here referred to, which have resisted the means hitherto employed.

To make the practical part of the subject as clear as the present state of our knowledge admits of, it is necessary to inquire into the nature of the powers of the more perfect animal, and the principles on which they co-operate with the powers of the inanimate world: and this is the more necessary, that, as fully stated in the preface, there is no other branch of physiology respecting which our knowledge has continued so defective, as respecting the laws of the nervous system, and the nature of its powers, on which all the more complicated functions of the more perfect animal in a greater or less degree depend.

The following is the first question which presents itself in such an inquiry. Are there any of the powers of the more perfect living animal which it possesses in common with inanimate nature?

With respect to two of these powers no doubt can arise. It is evident that the living animal possesses the mechanical power in common with inanimate nature. Its laws are the same in both. In both, for example, velocity can only be obtained by the sacrifice of power. It is equally evident that the changes effected in the blood, for example, in the course of circulation, and the opposite of these

changes effected in its passage through the lungs, depend on the same laws which operate in the chemical changes of inanimate nature. These changes are identical.

We are now to inquire how far either of the powers which effect these changes in the living animal is derived from the same source as in the inanimate world; for, however identical the powers, it does not follow that their sources are the same in both.

It is evident to the most careless observer, that the mechanical powers of the living animal derive their source from a vital power strictly so called, that of the muscular fibre, there being no power of similar properties in the inanimate world. However identical the mechanical power of the muscular fibre may be with other mechanical powers, it is evident that the muscular fibre possesses other properties which distinguish it from all the powers of inanimate nature. We can substitute no power of inanimate nature for the functions of that fibre.

For the purpose of determining this question respecting the chemical powers of the living animal, I made many experiments, an account of which the reader will find in the Philosophical Transactions of London for 1822 and 1836, and their results more concisely recapitulated in the last of these years. In the second part of the fourth edition of my Inquiry into the Laws of the Vital Functions, published in 1839 *, compared with the late experiments of Dr.

* In the end of 1815, I laid before Sir Joseph Banks, then the President of the Royal Society of London, an account of experiments, the results of which, it appears, from what is said in the preface, have been publicly confirmed both in London and Paris, proving the identity of the nervous influence and voltaic electricity.

Faraday, an account of which is published in the Philosophical Transactions of London, and in his treatise entitled, Experimental Researches in Electricity, published in 1839, it appears that the chemical powers of the living animal are derived from the same source as those of inanimate nature, namely, the electric power, which, from its being applied by the nerves, has, in the living animal, obtained the name of the nervous power or influence, the only one of those powers which have been regarded as peculiar to the living animal, which it possesses in common with inanimate nature; the source of the sensorial and muscular powers, and the powers of the living blood, being peculiar to it alone.

That it possesses the source of the nervous power in common with the world which surrounds it, appears from the most conclusive of all tests, which has been publicly repeated both in London and Paris, and on a great variety of animals, with the same result, namely, that when a certain modification of electricity (voltaic electricity) is supplied in sufficient power, and made to operate under the same circumstances under which the nervous influence operates in the functions of life, after that influence has been wholly removed, and its functions in consequence have wholly failed, they are as perfectly performed by voltaic electricity as if the nervous influence itself had been restored: and as we have no means of distinguishing any power but by its effects, the identity of the effects necessarily implies that of the power, as far as relates to its general nature.*

* The experiments by which the positions here referred to were ascertained, I made as early as the year 1815, and before the end

Such then, it appears, from facts which I believe are now generally admitted, is the peculiarity of the nervous power, the leading power in the vital system of the more perfect animal. It is an agent in common to the animate and inanimate world, but much influenced in its effects, we shall find, in the former, by the vital powers of the living animal, with which it is there associated: and it will appear, from what is said in the second part of this volume, that we are in many instances not a little assisted by this knowledge in the cure of diseases arising from or influenced by the state of the nervous power properly so called: and amongst other ways in which it affords practical assistance, it has enabled us, as I have already had occasion to observe, to draw a correct line of distinction between the sensorial and nervous powers; the want of which has been, in many ways, felt in our profession.

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of that year communicated their results to Sir Joseph Banks, then President of the Royal Society of London, in a paper which, as appears from the following extract made by the secretary of the society, from the forty-second volume of its records, was laid before the Society on the 25th of January, and the 1st and 8th of February, 1816; although, for reasons detailed in the fourth edition of my Inquiry into the Laws of the Vital Functions, its contents were not published in the Philosophical Transactions till the year 1822.

Extract from the records of the Royal Society by the secretary of the society. "Dr. W. Philip's paper, entitled, 'Further Experiments and Observations on the Relation which subsists between the Sanguiferous and Nervous Systems, particularly on the Nature of Secretion, the Use of the Ganglia and Cause of Animal Heat,' was in part read on the 25th January, 1816; it was again resumed on the 1st of February in the same year, and concluded on the 8th February." See the Journal of the Royal Society, Vol. XLII., page 52. See also the Appendix to this volume, No. I.

No less striking a peculiarity, but one of a very different nature, distinguishes the sensorial power, the leading power in the sensitive system.

As the nervous power is the only one of those powers supposed to be peculiar to the living animal, which has been found to be common to it and inanimate nature, the sensorial power is the only one which, from possessing none of the properties of inanimate nature, is wholly incapable of any direct intercourse with any of its agents.

We at once perceive that the striking analogy observed between all the other functions of life and the operations of inanimate nature—for example, between the chemical changes effected in the blood, both in the course of circulation, and the reverse of those changes effected in it in its passage through the lungs—bear the strongest analogy to certain changes effected in inanimate nature. In the functions of the sensorial powers all trace of any such analogies forsakes us. Sensation and volition, for example, bear no analogy to any of the operations of inanimate nature.

The sensorial power possessing none of the properties of inanimate nature, and thus being incapable of direct intercourse with its agents, is yet, as appears from a thousand phenomena, enabled to act in concert with them. By what means is this result effected?

The organs of all living powers, with the exception of those of the sensorial powers, retain certain properties of the matter of which they are composed; while in the living animal they acquire, from their endowment with the vital principle, a capability of acting in direct concert with organs possessing vital

properties alone, as far as they are brought into contact with such organs.

Thus we have seen, from the relations which exist between the sensorial and nervous powers (notwithstanding the latter being in common to the animate and inanimate world), these powers brought immediately under the influence of each other; a fact on which so many of the phenomena of the more perfect living animal depend.

There is but one class of organs in the more perfect animal which may be said to come into contact with, and is called upon for immediate intercourse with, any of the organs of the sensorial powers, namely, those of the nervous powers properly so called. They are the only organs which can directly excite the sensorial powers, that is, through their nerves, and the nerves of the sensorial powers; (which, as neither set of nerves can originate any change, may themselves be regarded as parts of these two classes of organs.) This is the only medium through which the sensorial powers can be directly influenced; and, in fact, the only case in which any other organ comes into contact with any sensorial organ. Thus it is that the organs of the nervous powers properly so called are the only means which can directly influence the sensorial powers; while the nervous powers themselves, in consequence of their organs retaining some of the properties of the matter of which they are composed, are influenced in other ways and by other means. They are thus enabled, on the one hand, to receive and propagate impressions from the agents of inanimate nature, whether existing within, or only occasionally introduced into, our bodies, or applied to the various organs of sense distributed over

their surfaces, and, on the other, in consequence of their vital properties, directly to influence the organs of the sensorial powers.

Such are the means by which impressions made by the agents of the external world excite the organs of feeling, volition, and all other functions of the sensorial organs.

But these functions, we find, are also capable of influencing the agents of the external world, as well as of being influenced by them; otherwise the influence exerted on the sensorial organs by that world would have been in a great degree useless.

The means by which the sensorial organs influence the agents of the external world are more complicated, but equally evident when the laws of our system are borne in mind.

The nervous power properly so called, it appears from all that has been said, is under the immediate influence of the sensorial powers; and when we wish to influence the agents of the external world, we have but one means by which this can be done. The muscles of voluntary motion are called into action by the application to them of the nervous power properly so called, that is, as appears from what has been said of voltaic electricity, which is found by direct experiment to be the most powerful of all the stimulants of the muscular power placed through the vital properties of the organs of the nervous powers, immediately under the influence of the sensorial powers.

In this way alone can the sensorial powers influence the external world; and by the means just detailed, the agents of the external world become the sole intermediate link by which the whole powers of the living animal are elicited. The capabilities of

the animal are the immediate gift of the Creator; but the stimulants which call its powers into action are always directly or indirectly the same—the agents of the external world. We see this well illustrated by the perfect fœtus immediately before it is brought into the world. Its powers, with the exception of respiration, are complete; but its actions how confined,—exactly in proportion to the confined degree in which it is exposed to those agents, for all are the agents of the external world which are external to the organs of the sensorial powers, whether they exist in our own bodies or elsewhere. I here beg leave to quote the following passage from the paper which the Royal Society did me the honour to publish in the second part of the Philosophical Transactions for the year 1836, which forms the concluding part of what is there said on this subject, namely, the relation which the living animal bears to the world which surrounds him, and which requires some consideration to be fully understood.

"The great variety of the phenomena of life is one cause of their apparent obscurity. Such is their variety, that we are at first view lost in attempting any arrangement or even enumeration of them. An essential step towards their arrangement, as appears from what has been said, is their division into those which are the immediate results of the co-operation of the principle of life with the principles of inanimate nature, and those which have no immediate dependence on the latter powers; for all our functions mediately or immediately depend on the operations of the agents of inanimate nature. All are more or less directly excited by impressions originating in their agency.

"The most purely sensorial functions, our pleasures and pains, are as dependent, though more remotely, on the excitement maintained by them, as the functions of the organs immediately impressed by them. Have not the excitements of memory as much originated in their impressions, as their more direct effects on the part impressed? And when the nature of our bodies and the circumstances in which we are placed are duly considered, what other result could be expected? Our organs, being composed of the same materials as the world which surrounds us, can only be directly influenced by agents of their own nature; and from that world, and by the medium of those organs, all the materials, not only of our acquired knowledge*, but of our enjoyments and our sufferings, are derived.

"And as, on the one hand, all our functions are more or less immediately excited by impressions made by the agents of the external world on organs composed of materials of their own nature; on the other, we have no power of influencing them, but through similar means. The only means of exciting our mental functions, we have seen, are the impressions of those agents on the organs of sense; and our only means of operating beyond our own bodies are through our organs of motion. Even when by our

* We are born with the knowledge which is immediately essential to our existence. The infant knows as well how to suck and how to breathe as the adult. Such knowledge is called instinctive, because it is not the result of experience; but it is no less true that both acts are voluntary, no muscles are employed in either, except those which are excited by the will alone. See my papers in the Philosophical Transactions for 1833 and 1834, on the nature of sleep, and on the nature of death; also Appendix, No. II.

mental powers we influence those of other sentient beings, it is as much, though not so directly, by impressing the agents of the external world by the latter organs, as when we raise a weight or throw a stone."

It appears, from what has been said in the preface, that the peculiarities of the treatment of disease recommended in this volume are founded on the results of the investigation by which the positions which have been stated were ascertained. I shall here select those positions on which the peculiarities referred to more immediately depend, and endeavour to place them in so simple a point of view that the general reader may understand them.

There has not been in our profession, we have seen, any decided opinion either respecting the general nature of the nervous influence, or the functions to which its powers are limited; amongst other consequences of which are, that no well-defined line has been drawn between the functions of the nervous and sensorial powers properly so called; and even what organs are employed in the formation of the nervous influence, we shall find, had never been ascertained.

I have already had occasion to point out that the nervous power properly so called is the leading power in the vital system; that is, is not only the chief power employed in all its more complicated functions, but also that power which controls all the other powers employed in them; and it is consequently on this system that the various phenomena both of health and disease more immediately depend. It is only, as appears from what has already been said, through the intervention of the nervous system

properly so called, that the sensorial power, the leading power in the sensitive system, having no direct influence on the vital organs, can influence the states either of health or disease.

If such be the facts, and the general nature of the nervous power be such as stated in this volume, as the first physiologists, both of this country and the continent, I believe, now admit; it becomes an object of no small consequence in the treatment of disease, accurately to ascertain the organs which supply it: by which we have reason to believe that considerable light must be thrown on the treatment of those diseases, a very numerous and important class we shall find, which have their origin in diseased states of this power, or, more correctly speaking, of the organs on which its supply depends; for if what has been stated in this volume respecting the nature of that power be correet, the nervous influence itself cannot be the subject of disease. It can only vary in quantity according to the state of the organs by which it is supplied. I have had occasion to observe in the preface, that while our knowledge of the animal economy has in almost all other departments been improving, little or no addition has been made to it in the department of the nervous system during several centuries. The same ignorance of the nature of the nervous power itself, and the same errors of doctrine respecting it, and even respecting the organs which supply it, which we shall find have so unfavourably influenced the practical department of our profession, influence it still.

I shall here confine myself to the facts which it is necessary for the reader to keep in view in order to understand the principles of the treatment recom-

mended in the present volume. The proofs of those facts he will find in twelve papers published in the Philosophical Transactions of London, between the beginning of the year 1815 and the end of 1836, and the fourth edition of my Inquiry into the Laws of the Vital Functions, published in 1839; from which, among the other positions ascertained by the experiments detailed in these works, it appears that the brain and spinal marrow are the *only* organs which prepare the nervous influence properly so called.

It has been, and still is supposed that the ganglions and plexuses prepare that nervous influence which operates in the vital system, because it was observed by the anatomist that all vital organs are supplied by nerves issuing from them; but they, and the other ganglionic nerves, we shall find, perform functions of a wholly different nature. It appears, from a paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions of the year 1829, that they are incapable of supplying any influence which in any way controls the vital organs; while, on the other hand, it appears, from other experiments already referred to, that they are only the means of combining and directly conveying the influence of organs distributed through all parts of the brain and spinal marrow, to every part of the vital system, however distant and minute; for, as it also appears from direct experiments, there is not one of the minutest capillary vessels, too minute to be seen without the aid of the microscope, that is not capable of being influenced by every part of both of these organs, from the uppermost surface of the brain to the lowest portion of the spinal chord; and that, not through the intervention of other active

organs, as the brain influences a large proportion of the muscles of voluntary motion, through the spinal marrow, but directly by nerves which, themselves, can originate no change, sent by means of the ganglionic system to each individual part of the vital system, however distant and minute; the combined power of the whole brain and spinal marrow, being required for the formation of the nervous influence employed in all, even the most minute, vital organs.

If any considerable portion of either the brain or spinal marrow be removed, or their functions in any way impeded, the vital powers of the whole system are found to fail exactly in proportion to the extent of the part so destroyed or impeded in its functions; and if the nerves which convey from the ganglionic system the combined influence of every part of these organs to any particular part of our frame be prevented from conveying it, the vital organs of that particular part lose their functions, while those of all other parts remain, except as far as they are affected by the loss of power in the former organs, provided the brain and spinal marrow be left entire; both results proving that it is the failure of this particular nervous influence, which takes its origin from all parts of the brain and spinal marrow, and is distributed to the vital organs alone, which is the cause of those results. Such appears to be the sole uses of the ganglious plexuses and other nerves which belong to the ganglionic system. This system combines and conveys to the vital organs in all parts of the frame the influence of organs distributed through every part of the brain and spinal marrow; but is, itself, wholly incapable of preparing any part of that influence.*

* See a paper, entitled "On the Relation which exists between

Thus it is that the functions of the ganglionic system have necessarily remained unknown, till it was found that the nervous influence bestowed on the vital organs requires for its formation the united power of organs distributed through every part of the brain and spinal marrow. It is evident, therefore, that till this knowledge was acquired we possessed no data by which the uses of that system could be ascertained.

It is easy for the anatomist to determine that the vital organs are all supplied with nerves which proceed from the ganglions and plexuses; but many of the parts concerned are too minute for his observations, to admit of his tracing the connection of nerves which exists between the brain and spinal marrow and the ganglionic system. This connection, however, as we have seen, can with ease be traced by the experimentalist. It appears, from what has been said, that experiments, of too simple a nature to admit of deception, at once prove the immediate and universal influence which exists between the brain and spinal marrow and the ganglionic system, which, it appears from these experiments, derives all its powers from those organs, being, itself, wholly incapable of producing any nervous influence properly so called; an oversight which has produced, as will appear from what is said in the second part of this treatise, the most fatal effects in an extensive class of diseases; because it having been supposed that the brain and spinal marrow have no influence on the vital organs, it was a necessary inference that they

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the nervous and muscular systems in the more perfect Animals;" which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1833; also Appendix, No. III.

cannot, in any degree, either cause or regulate their diseased states.

Thus it is that Dr. Alison, Professor of the Institutes of Medicine in the University of Edinburgh, which may be regarded as one of the first medical schools, has in a late publication, entitled "A Dis-"sertation on the State of Medical Science, from "the Termination of the Eighteenth Century to the "present Time (1834)*," made the following statements: —

"In regard to the functions of nutrition, secre-"tion, and excretion, to which the circulation is sub-"servient, perhaps the most important information "lately obtained is of a negative character. Not-"withstanding the opposite opinion of some eminent "physiologists, it may be stated as the general belief, "and as a fair inference from a review of the different "departments of living beings, as well as from ex-"periments and observations on the higher animals, "that these processes are independent of any influ-"ence or energy necessarily derived from the nervous "system."

From the first part of the present volume it appears, and that from experiments the accuracy of which have now been admitted by the first physiologists both of this country and the Continent, that the foregoing positions of Dr. Alison, although he is right in stating them to be at present the general belief of the profession, are wholly unfounded; the brain and spinal marrow being the only organs which supply the nervous influence properly so called: and from the second part of this volume it appears to

* See the Cyclopædia of Practical Medicine.

how extensively fatal a result this misconception has led in the practical department of our profession,—one of the causes, indeed, as stated in the preface, of the present publication.*

In consequence of the nature of the nervous influence properly so called not having been understood, all our knowledge respecting this branch of physiology has been confused and unsatisfactory. It has been supposed that all nerves convey a similar influence, nor am I aware that any attempt has been made to distinguish its different species. Although their properties, we shall find, are of the most dissimilar nature, we speak as if there were but one species of this influence; and it seems to have been taken for granted that such is the case, the question, as far as I know, never having been made a subject of inquiry. When the whole of the facts which have been laid before the reader in the Philosophical Transactions, and my Inquiry into the Laws of the Vital Functions, are duly considered, it will be found, as stated in the preface, that there are three different species of nervous influence, each conveyed by its own class of nerves, of essentially different properties

* The first edition of my Inquiry into the Laws of the Vital Functions was published as early as 1817, and an account of the experiments respecting the nature of the nervous influence was laid before the Royal Society as early as January 1816 (see memorandum of this in the Records of the Society, Vol. XLII. p. 52.; and also the Appendix to this volume, No. IV.), although no account of them appeared in the Philosophical Transactions till the year 1822, when the experiments on this subject were publicly repeated, by direction of Sir Humphrey Davy, then president of the Royal Society, at the rooms of the Royal Institution; Sir Benjamin Brodie having done the author the honour of offering to operate under his direction.

and origins; and so much is this the case, that the three species have not even one property in common; and nothing can be more strikingly dissimilar than their origins, nor has there been any distinct idea of the properties of any one of these species, nor of the functions to which their different powers are limited: the consequence is, that, no well-defined line having been drawn between the nervous and sensorial powers properly so called, the subject is still farther involved.

The three species of nervous influence, namely, that of the nerves of voluntary motion, that of the nerves which maintain the functions of assimilation, secretion, and excretion, and by which the muscles of involuntary motion are excited, and that species conveyed by the nerves of sensation, each belong to a class of nerves of wholly different origins from each other.

The nature of the nervous influences conveyed by the two first classes of nerves so far resemble each other, that all their powers are chemical; but in other respects these influences are of the most dissimilar nature. Even the excitement of the muscular fibre does not, in both classes of nerves, obey the same laws. The influence conveyed by the remaining class, the nerves of sensation, has no property whatever in common with that conveyed by either of the two former classes.

The influence conveyed by the first class, those of voluntary motion, possesses a simplicity of function corresponding to that of its origin, each nerve arising from one particular part, either of the brain or spinal marrow, no other parts of these organs being capable of influencing them, and the only function of each

nerve is that of exciting particular muscles of voluntary motion.

Of a far more complicated and important nature are the functions as well as the origins of the influence conveyed by the second class of nerves. While it is the means of exciting the muscles of involuntary motion, it is the chief agent in all the functions of assimilation, secretion, and excretion, on which the formation and maintenance of our frame immediately depend; the source from which it derives these complicated powers is in the same degree complicated, compared with that from which the influence conveyed by the nerves of voluntary motion derive their only function. We have just seen, in the latter class of nerves, each nerve taking its origin from only one particular part, either of the brain or spinal marrow; while it appears, from the experiments above referred to, that the second class of nerves have their origin in every part of those organs, the powers of which, by the arrangements of the ganglionic system, are combined and directly bestowed on every the most minute vital organ, even a capillary vessel, as above observed, so small as to be invisible without the aid of the microscope.

The influence conveyed by the nerves of sensation, although in all respects so dissimilar in its nature from that conveyed by the first class of nerves, yet resembles it both in the simplicity of its function and the origin of its nerves.

When we turn to the species of nervous influence conveyed by the nerves of sensation, we find ourselves, as when we turned from the other functions of the more perfect animal to those of the sensorial power, in a new world. The striking ana-

logy which subsists between the operations of the two species of nervous influence we have been considering and the phenomena of inanimate nature wholly forsakes us. In the influence conveyed by the nerves of sensation we find no property that bears the least resemblance to a chemical process. It has, I have just had occasion to observe, like the influence conveyed by the nerves of voluntary motion, only one property, and its nerves but one origin,—but, in both instances, of how wholly different a nature. The one excites the muscular fibre alone, the other the sensorial powers alone; the phenomena of which bear not the most distant analogy to any of the operations of inanimate nature. The nerves of the one arise from particular parts of the brain and spinal marrow alone; organs which, although themselves insensible, bestow sensibility on other parts; those of the other, from all sensitive, but no other, parts. The nerves of sensation form no part of the nervous system properly so called; they belong to the sensorial system, and have only from their resemblance to the former nerves been associated with them. The property of the influence they convey has nothing in common with the influences conveyed by the two first classes of nerves. It is only required where sensorial organs exist, of which we have seen it is the sole direct stimulant; other agents, instead of exciting their functions, tending directly to destroy their powers.

All the functions of the two first classes of nerves being chemical, we have reason to believe, from the usual simplicity of the works of nature, that they depend on the same agent that operates in the chemical changes of inanimate nature; an inference which ap-

pears to be confirmed by the late experiments of Dr. Faraday*, for it appears from them that all chemical processes are electrical phenomena. Dr. Faraday obliged me by addressing to me the following letter, with permission to publish it: —

Royal Institution,
10th Nov. 1841.

My dear Sir,

I find, by looking over my papers, that the first free expression of the opinion that chemical and electrical force is essentially the same, is in paragraph 877. in the seventh series of Experimental Researches read to the Royal Society, April, 1834. Previous expressions may be found in paragraph 377. January, 1833, and paragraphs 713. 783. 850. January, 1834, showing the gradual progress of the idea in my mind; the full conviction of its truth is stated in the sixteenth and seventeenth series, January, 1840.

Ever, my dear Sir,
Your faithful servant,
M. Faraday.

Dr. W. Philip.

Thus, at the distance of five and twenty years, have my inferences respecting the nature of the nervous influence derived no trifling support from the labours of this philosopher, so celebrated, particularly in the chemical departments of science.

It was the striking analogy which exists between all the immediate effects of the nervous influence properly so called, that is, the influence conveyed by the first two classes of nerves, and the chemical phe-

* See Philosophical Transactions of London.

nomena of inanimate nature, together with the great chemical powers of the living animal and of voltaic electricity, that first led me to suspect that the cause which immediately operates in both must in its general nature be the same; and the circumstance of voltaic electricity being the best known stimulant of the muscular fibre, appeared to confirm this inference; for it is consistent with what we observe of the wisdom of Nature, that the means best fitted for her purpose should be chosen.

The stimulants of the inanimate world, as may be inferred from what has already been said, are, directly or indirectly, the only stimulants of all our organs, even those of the sensorial powers, which can only be excited through the nerves of sensation; for the nerves of sensation, we have seen, retain enough of the properties of the matter of which they are composed, to be excited by the stimulants of inanimate nature, and thus to act in concert with its agents, and to propagate the impressions made by those agents.

It appears, from the investigation on which this volume is founded, that all the phenomena of the sympathy of parts, a law which more than any other of our frame influences the progress of disease, and particularly of the most important class of the diseases treated of in this volume, take place through the medium of the central organs, the brain and spinal marrow, and in no instance in consequence of the connection of nerves in their progress to the parts they supply; the brain and spinal marrow being the only active, the nerves always the passive, parts of the nervous system. The latter possess no in-

fluence but that which they receive and convey from the former organs; and therefore, as I have already had occasion to observe, can originate no change.

After due preparation in the stomach and duodenum, that is, the intestine into which the stomach discharges the food after it has in the stomach been brought into the state we call chyme, (for the digestion is not completed till the contents of the stomach are mixed with the bile and other juices poured into this intestine, which may be regarded as a second stomach; in which our food is formed into what is called the chyle, that is, food in the state in which it is duly prepared for being converted, by the chemical powers of the nervous influence properly so called, into the various organs of our bodies,) it then enters the remaining part of the alimentary canal, which in the human body is of great length, and copiously supplied with absorbent vessels, by which the chyle is taken up and conveyed into the general mass of blood, and thus supplied to all parts of the body; the changes by which the chyle is formed in the stomach and duodenum, and those by which it is converted into the various organs of our bodies, being both the immediate effect of one agent, the nervous influence properly so called, supplied, in the way above explained, by the brain and spinal marrow alone; the nature of which we have fully considered, as far as we can ascertain the nature of any power; that is, we have ascertained what power operates in its phenomena, by experiments the results of which are now generally, both in this country and abroad, admitted to be correct; and by this knowledge, as I have already had occasion to observe, we find we

have been enabled essentially to improve our treatment of disease.

It farther appears, from the same investigation, that the capillary vessels perform a more important part in the circulation than has been ascribed to them.

Many experiments detailed in the papers above referred to in the Philosophical Transactions, and in the fourth edition of my Inquiry into the Laws of the Vital Functions, prove that the influence of the contractions of the heart does not extend to the capillary vessels. If a ligature be thrown round all the vessels attached to the heart, and the heart cut out, no change in the motion of the blood in the capillary vessels takes place; the blood continues to move in those vessels in precisely the same way, and with precisely the same velocity, as while the circulating system was entire, and the heart beating as in health; and only fails as the supply of blood from the larger arteries fails; being supported in the healthy animal by the power of the vessels themselves, which possess all the properties of a muscular power.*

It thus appears that both the nervous and muscular powers of the capillary vessels are provided for with a care proportioned to the importance of the functions they perform; for all the functions of assimilation, secretion, and excretion are effected by the action of that nervous influence which is prepared by all parts

* See my paper On the Powers of Circulation, in the Philosophical Transactions for 1831, Part II., and the fourth edition of my Inquiry into the Laws of the Vital System; also Appendix to this volume, No. V.

of the brain and spinal marrow, and applied by the minute extremities of the nerves to the blood conveyed by the capillary vessels on which they are distributed; each, even the most minute vessel, as above observed, receiving its nervous influence directly from every part of the only organs which supply that influence properly so called, and possessing a muscular power capable of supporting the due motion of the blood, altogether independently of aid from any other organ, and by the peculiar origin and distribution of their nerves placed under the same complicated influence, that of every part of the brain and spinal marrow which is required for the functions of assimilation and secretion.*

All the functions of the nervous power are effected by the minute extremities of the nerves, which, on the one hand, are intimately blended with the muscular coat of those vessels, and, on the other, brought into contact with the fluids they convey; the blood, from their lessening capacities, being mechanically divided in them into red and colourless, in all organs where the functions of assimilation and secretion are performed; from which we may infer that this division is essential to the changes necessary to the due performance of those functions: and we have just seen that the nervous influence which effects these changes, which are all chemical, is of the same general nature with the chemical agent which operates in inanimate nature.

We thus, together with what has been said of the

* As soon as it was ascertained that any part of the blood passes through a second set of capillary vessels before it returns to the heart, we might have been assured that the motion of the blood in them is independent of the action of the heart.

processes of the digestion and distribution of our food, arrive, as nearly perhaps as we can ever expect to do, at a knowledge of the functions which immediately maintain life; namely, the immediate means by which our food is converted into the various organs of our frame.

Of the principle of life, as of other powers, we can know nothing but its properties: any more intimate knowledge of any principle is not merely beyond the limits, but the nature, of our minds. When we make ourselves acquainted with a property of any principle previously unknown, and class it with the other phenomena of that principle in a clear and satisfactory manner, we consider ourselves as understanding the nature of that property; and justly, both because the human mind can go no farther than ascertain the principle on which any particular phenomenon depends; and, if it could, in our present state we can see no useful application which could be made of such knowledge. We have determined, for example, that the general nature of the phenomena of the nervous influence properly so called, and voltaic electricity, are essentially the same; and this knowledge, we shall find, leads to a more successful treatment of certain diseases. Of an intimate knowledge of the nature of the principle on which these phenomena depend, in the present state of our being, what use could be made? Our aim is to class together the whole of the phenomena of each principle, that we may distinctly perceive where each operates. This alone is the knowledge which can prove useful to us, and the only knowledge which we possess, or ever can possess, of gravitation, or any other principle the most familiar to us.

It saves much useless labour, in all inquiries, in the first place to determine what is attainable, and in the second, that which, if attained, will be useful: precautions often neglected in those disquisitions which have no immediate connection with the common affairs of life; such as inquiries into the nature of the vital principle, &c. &c.; in which men of considerable talents, in our profession and others, have often most uselessly employed themselves; for even such writers as Hartly and Hunter are liable to this charge. It is Haller's greatest praise, that, having been more than any other physiologist of his time engaged in physiological discussions, he avoided such errors. He may be regarded as the first who, to any great extent, introduced the principle of correct induction into such discussions; and although, from too hasty inferences, he was occasionally led into error, — as in some points respecting the relations which subsist between the nervous and sanguiferous systems, — I think we cannot help regarding him as the greatest reformer of our physiological systems. His discussions relate to no subjects, on which all labour must, in the nature of things, be useless. From the state in which he found physiology, it is not surprising that some of his inferences had been too hasty to be correct; that, considering the state in which he found the subject, he sometimes failed in not having taken the whole of the circumstances into due consideration.

From our finding that the ganglionic nerves possess the property of exciting the muscular fibre, it has been supposed by some that they are accompanied by the same class of nerves which excite

the muscles of voluntary motion, bound up in the same sheath with them, and that to this they owe their power of exciting the muscular fibre. This opinion is proved to be erroneous, however, by a circumstance to which I have frequently had occasion to refer, and which has been ascertained by frequently repeated experiments *, — that every capillary vessel of the system may be directly excited by stimulants applied to any considerable portion of either the brain or spinal marrow; whereas the muscles of voluntary motion can each be directly excited only by certain small parts of one of those organs from which its nerves arise, and convey the influence of those parts alone. The capability of exciting the muscular fibre through the ganglionic system of nerves, is as much a property of the whole brain and spinal marrow as the other properties of this particular class of nerves, manifested through that system; and therefore must be performed by a class of nerves wholly distinct from those which convey a power originating from a very different source, which belongs only to certain small portions of them. Besides, I have already had occasion to observe, that the excitement of the muscular fibre by the two sets of nerves does not in all respects obey the same laws: its excitement by the one is always an act of volition; by the other, wholly independent of the will: nor does the latter set of nerves influence the muscular fibre of the newly dead animal in all respects in the same way that the former so readily does.

* Philosophical Transactions, and the fourth edition of my Inquiry into the Laws of the Vital Functions.

Another point which particularly demands the reader's attention, the importance of which has either been wholly overlooked or too little attended to in the practical department of our profession, although in many respects evident from the daily phenomena of our lives, and, in not a few cases of both acute and chronic disease, an attention to which is essential to recovery, and in none more than in the principal class of the diseases we are about to consider, is, that the organs of the vital and sensitive systems obey very different laws. All degrees of excitement tend, more or less, to produce corresponding exhaustion in the organs of the sensitive system. The consequence of which is, that however free from all excitement its organs can be kept without their abstraction proving fatal*, the effects of that which remains debilitate, and at length wholly destroy, their powers, to which intervals of comparative rest are essential. By the laws of our frame, when exhausted to a certain degree, the general case is that they cease to be excited, which occurs more or less rapidly, according to the circumstances in which we are placed, and if the exhaustion is general and complete, the patient dies; for we have seen that in the more perfect animal the sensitive functions are as necessary to the continuance of life, respiration being in them a function of volition, as the circulation itself. It is only their partial exhaustion which is unattended by danger. In the soundest sleep we still perceive the sensation which

* It appears from statements above referred to, that respiration is no less an act of volition, although, from its frequent and habitual recurrence, we are less aware of its being so than in those acts of volition which recur less frequently.

induces us to inspire, and drawing the air into the lungs is still an act of volition.*

The organs of the vital system, in health, always retain their powers unimpaired by the daily excitements of life, and in the interval of the partial repose of the sensitive organs, afford ample means for the restoration of their powers. But were the vital organs subject to the same exhaustion, as no means are provided for their restoration, all their functions while life lasts being incessant, our lives at most would be of but a few days' continuance. They suffer no sensible exhaustion from the daily stimulants of life, unless these stimulants become such as to excite them beyond the degree necessary to their healthy functions.

In the first stage of fever, for example, the heart and vessels of circulation are excited beyond that degree. The necessary consequence is, that their powers become more or less impaired in proportion to the degree and continuance of the morbid excitement, and the safety of the patient depends on the removal of that excitement before it has so exhausted their powers that they can no longer support the circulation. What is called the turn of the fever, that is, the period at which the increased action of the heart and vessels (either in consequence of their powers being impaired by the continuance of the excitement, or its causes having been removed) is changed to a state of general debility, determines the fate of the patient. It follows, of course, that the sooner the morbid excitement has been

* See my papers published in the Philosophical Transactions for 1833, on the nature of sleep, and from which an abstract is given in the Appendix, No. VI.

relieved the less debilitated the powers of circulation will be left, and, consequently, the more capable will they be of still supporting it; and when they are found so, the causes of the fever having ceased to operate, if their exhaustion has not gone too far, all the vital functions, though debilitated, remain, and gradually regain their healthy vigour.

Similar observations apply to the functions of all other vital organs in their various diseases, for the total failure of any one essential to life of course proves fatal to all; although the less evident the disease, and the less rapid its changes, they are the less readily observed.

While the excitability of the sensitive organs, in health, is impaired by the stimulants of the day, to be restored by the rest which follows it, that of the vital organs, while health continues, is only sensibly impaired by the stimulants of life, of which their exhaustion determines the natural duration.

As the vital organs are endowed with an excitability to last through life, in infancy they possess a degree of it which exceeds that most conducive to a firm state of health, — the cause of many of the most fatal diseases of this period. The irritation of stomach which in the adult produces restlessness and dejection, in the infant may produce convulsions and death. The derangement of the biliary system which in the adult produces depression of spirits, in the infant, if neglected, often produces the effusion called water of the head.

We have reason to believe, as I endeavoured to point out in a paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1836, and in the fourth

edition of my Inquiry into the Laws of the Vital Functions, from the former of which the reader will find an extract in the Appendix, No. VII., that this excess of excitability is necessary to the growth of our frame. The excitement produced by the usual stimulants of life being greater than the maintenance of our organs requires, they enlarge. Greater excitement being produced than is necessary for their maintenance, more materials are animalized. As the continued application of the stimulants of life by degrees lessens the excitability of the vital organs, the powers of the system improve, till the remaining excitability is in due proportion to the causes which support the healthy excitement; and this seems to be the limit at which the growth ceases; and when a certain time has elapsed after this period, the fault becomes a deficiency, not an excess, of excitability, which necessarily daily increases, till, the excitability of some one or more of the vital organs being exhausted, death is unavoidable.

Hence it is that those who during life have been exposed to powerful and long-continued causes impairing the excitability of the vital organs, whether causes affecting the mind or body, rarely attain a great age, for all affections of the one more or less influence the other; and that the excesses of youth, particularly if they have been long continued, are often more felt in advanced life, when the excitability begins to be more or less defective in all, than at earlier periods; many instances of which I have witnessed.

On comparing together the statements relating to the nature and distribution of the various parts of the

nervous system made in the preceding pages, we readily perceive the cause of that general sympathy which prevails throughout the frame of the more perfect animal, and which, we have seen, so powerfully influences the course of disease. I shall here, although I have already had such frequent occasion to refer to it, attempt to bring into one view the different facts relating to it. We find a set of organs distributed throughout the whole of the brain and spinal marrow, which may be justly termed the organs of life, because they supply, we have seen, the agent by which, on the one hand, our food is in the first place properly changed in the stomach and duodenum to prepare it for the changes effected in the capillary vessels; and, on the other, those changes themselves are effected; by both of which sets of changes our food is converted into the various organs of our bodies; and these changes are not only wholly, but immediately, dependent on an agent, we have seen, of the same general nature with that which we see effecting similar changes in the world which surrounds us. Each individual part of the brain and spinal marrow, we have also seen, influences every part of the general frame; every part of the general frame, in its turn, being capable of influencing all parts of those organs.

To these laws there is evidently no exception with respect to all parts to which the nerves and blood-vessels have access; and as to those to which neither has access, as the cuticle and nails, even they are indirectly influenced by them; because, although these organs have no immediate dependence either on the state of the nerves or blood-vessels, they have an indirect dependence on both, which is felt on every de-

viation from the healthy state of either ; both cuticle and nails becoming brittle, and, consequently, ill adapted to their functions, in proportion as the functions of either nerves or blood-vessels fail, because the healthy state of both is found to depend on that of the organs with which they are in contact, all the affections of which, more or less, influence those parts: and similar observations apply even to the hardest parts of the teeth, which possess neither vessels nor nerves. It appears, therefore, from the whole of these facts, all of which are proved by daily experience of the various affections of the more perfect animal, that, through the channels here described, there is no part of its frame which is not capable, more or less, of influencing or being influenced by every other ; and hence the means by which disease, and more particularly chronic disease, is influenced by continuance, in whatever part it may have originated, till by degrees, in proportion as the derangement is more or less influential, the whole powers of the system are destroyed : and this evil, we shall find, is greatly aggravated by disease so often commencing in parts of so little sensibility, that the attention is not excited by it till it is often too late to arrest its fatal termination ; so much so, that the medical attendant, the whole of the preceding circumstances not having been sufficiently taken into account, is often as little prepared for the fatal result as the friends of the sufferer.

From the facts here stated, we have no difficulty in perceiving why every part of our frame may influence every other ; each part of the brain and spinal marrow, as appears from direct experiment, influencing every other part of the frame, and the state

of every part of the frame more or less influencing every part of these organs.

Thus it appears that we have no occasion to have recourse to any supposed influence of nerves on each other, in consequence of which so much labour has, as far as I am capable of judging, been so uselessly bestowed; all the facts on the subject tending to assure us, that the nerves are mere channels of conveyance, both in the cerebral and spinal system; and, in the ganglionic system of combination and conveyance, the nerves themselves, as well as the ganglionic system, being wholly incapable of influencing, in any other way than those here mentioned, the powers communicated to them by the brain and spinal marrow alone. They are the mere passive parts of the nervous system, having no power to originate any change in the powers they convey and distribute; the brain and spinal marrow, whether in the vital or sensitive system, being the only active parts of those systems, that is, the only parts capable of receiving impressions from the nerves, and, in consequence of these impressions, originating any effect but those just stated.

Every derangement affecting any part of the system, however minute, being felt by every part of the vital organs of the brain and spinal marrow, and these organs being distributed through every part of them, it will easily be understood that when any permanent fret of nerve is established, in whatever part, it must tend, more or less, according to its degree and duration, to impair the powers of all parts of these organs, on which, we have seen, the healthy state of every part of the system depends; for such is the sympathy of all neighbouring parts, and particularly parts of the

same organ, that they always, more or less, partake of each others' affections. Thus it necessarily appears that any long-continued cause of nervous fret, by gradually impairing the power of the only organs which prepare the nervous influence, and thus lessening the supply of the power on which, we have seen, assimilation, secretion, and excretion immediately depend, must, more or less, endanger these functions; and in any vital organ which happens, from other causes, to be most disposed to disease, a permanent debility may, sooner or later, be established; and the central organs, the brain and spinal marrow, which, I have had occasion to point out, are the only organs which supply the power on which the healthy structure of all parts of our frame depends, having been previously debilitated, disease of function, wherever it occurs, in such cases is apt to run rapidly into disease of structure; and, the cause which produced the fret of nerve being often overlooked, in consequence of the physiological errors which have prevailed in our profession, the medical attendant, as I have already had occasion to observe, is sometimes as much surprised as the friends of the patient at the rapidity with which such cases often prove fatal.

Thus the constitution is gradually, and with no suffering but what assumes the form of what is called nervous complaints, supposed to be free from danger, undermined; and the patient sinks, without the original cause of the danger having been suspected, and, consequently, without any of those means having been employed which alone can arrest the progress of his disease; no means being capable of removing a disease if the cause from which it originated continues to operate. And to this cause alone, as will

more fully appear in what is said in the practical part of the present volume, thousands of lives which may be saved, are, in the present state of our profession, annually sacrificed in these kingdoms; where, I believe, as I have already had occasion to observe, we are entitled to say that our profession has long been, on the whole, better understood than in any other country.

In all the more perfect animals the organs of the sensorial power, the leading power in the sensitive system, are chiefly, and in man almost wholly, confined to the brain. Those of the leading power in the vital system, the nervous power, belong equally to the brain and spinal marrow, and to all parts of them, except that they are either in less number or of less power in the lumbar portion of the latter organ than in any other part of either of these organs; and neither of them, in the formation of the leading powers of the two systems, receives any aid from any other organ whatever. Other organs, we have seen, only contribute to the proper distribution of their powers, and, in the ganglionic system, to the combination as well as distribution of their powers.

For the cure of many of the diseases we are about to consider, in their advanced stages, it is necessary that their connection with their previous stages should be clearly understood.

The most frequent cause of a permanent fret of nerves, and, consequently, of all the mischief which ensues in the most important class of those diseases, are what are, very indefinitely, called bilious or nervous complaints; terms which are applied to diseases of very different natures and origins, which, previous

to the fret, that is, the irritation, of nerves, having become permanent, in many cases cause so little uneasiness, that the patient seldom consults the physician till his disease is so established that its removal requires a tedious treatment; and, what is a still greater evil, by obscuring the connection between the commencement of the disease, when it presents no formidable appearance, and its progress, tends wholly to obscure its nature, and thus renders its more formidable stages, according to our present plans of treatment, always, and, as I shall have occasion to explain, necessarily fatal. It often happens in such cases that the affection in which the disease originates is not sufficiently powerful to establish the more formidable stages of such affections, until some other cause, disturbing the nervous system, occurs to increase its tendency. When this happens, the report of the patient still farther misleads the physician, for he often regards the cause which aggravates the symptoms as the sole cause of his disease, wholly overlooking the milder symptoms which preceded it, the knowledge of which is absolutely necessary to enable the physician to cure his disease; and thus the connection between the present and early stage is farther obscured, on which the safety of the patient depends. In the following part of this treatise I shall point out the diagnostic by which the nature of the disease may at all periods be detected, and the changes which take place in it ascertained.

Such are the observations which it is necessary for the reader to keep in view when the treatment of the most important class of the diseases we are about to consider is laid before him, in the second part of this volume. In these diseases we shall find that

after a long continuance of bad health, and, in some cases, of severe suffering, but which is not such as, in the present state of our profession, is regarded as attended with danger, (the consequence of the present defective state of our physiological knowledge *,) a train of symptoms supervenes, which at length leaves no doubt respecting their fatal termination.

As the immediate cause which endangers life in such cases is always the debility of the brain and spinal marrow ; where there is a morbid debility of these organs established before birth, which is sometimes, though rarely, the case, of which I have seen several instances, a debilitated state of the digestive organs always, more or less, attends such cases, keeping up a train of symptoms, always obstinate, and, if more rapid disease does not destroy life, at length fatal. I need not say that such cases are generally incurable, at least do not admit of perfect cure. But that even these cases may be generally relieved, and the fatal termination delayed to a late period of life, I have reason to believe, from several such cases which have been under my care, by a mild alterative course of some continuance, and renewed as required.

* See a paper which the Royal Society did me the honour of publishing in the Philosophical Transactions for 1836, and the fourth edition of my Inquiry into the Laws of the Vital Functions, published in 1839; also Appendix, No. VII.

PART II.

THE APPLICATION OF THE INFERENCES FROM THE INVESTIGATION ON WHICH THIS TREATISE IS FOUNDED, WITH A VIEW TO IMPROVE THE TREATMENT OF DISEASE.

It will be generally admitted that, except as far as depends on the simple principle of employing the means which had been found useful in similar cases, the practical department of our profession rests wholly on our knowledge of anatomy and physiology, a knowledge of the structure and functions of the animal body.

From the first of these three sources (independent as it is of previous information, and exercising only the simplest faculties of the mind) all practical knowledge of the healing art possessed in the rudest state of society is derived. As the limited nature and uncertainty of such a source appear, we are led to the means of assisting it.

We by degrees perceive the necessity of distinguishing the local and general, and the more immediate and remote effects of our remedies; and soon find that, to make any considerable progress in such investigations, some knowledge of the structure and functions of the subject of our practice is necessary; and that in proportion as this knowledge is acquired, our means of relief become more effective.

When I entered on the investigation on which this volume is founded, all our doctrines, as far as respects the general laws of our frame, as appears from

what is said in the first part of my Inquiry into the Laws of the Vital Functions, were involved in a confusion which none of the facts, of which we were in possession, enabled us to unravel. I therefore began by repeating many of the experiments of the physiologists who had for their object the elucidation of those laws, at the head of whom I found Haller, Le Gallois, and Hunter. I found the results of their experiments such as they state them to be; but the inconsistency of their inferences left us no room to doubt that some of these are fallacious; which will not surprise us when we consider the state in which they found the subject: for anything that had been done respecting the general laws of the animal economy before their time was comparatively of little account, being in most instances either so evident as not to require the aid of experiment, or erroneous.

It had, however, the merit of being to a certain degree consistent — a consistency not difficult of attainment — because, as the test of direct experiment had been comparatively little resorted to, it was easy to make any supposition which was necessary towards attaining it; but after the time of Haller, who, I have already had occasion to observe, may be regarded as among the first of those physiologists who applied with any accuracy to physiological inquiries the principles of inductive reasoning, the dreams of the older physiologists began to share the fate they so justly deserved, and the consistency of our systems immediately suffered.

The few facts at first ascertained were stubborn things, and would not conform to the loose and fanciful theories which had prevailed. Thus difficulties arose, and, even so lately as at the time my

labours commenced, prevailed, we have seen, to so great a degree, and caused such confusion in our doctrines, that some despaired of seeing it effectually removed.

The subject of the present part of this volume naturally divides itself into two classes, the diseases which originate in the sanguiferous, and those which originate in the nervous system; the latter term being understood in its most extended sense, that is, as including the organs of the sensorial and nervous powers properly so called.

The former class is simple, comprehending but few diseases, but some of those equally important from their nature, their frequency, and their intimate connexion with a large proportion of almost all other diseases; the latter so complicated, and of such variety, that, beside the diseases which originate wholly in the state of the nervous system itself, they comprehend, we shall find, certain modifications of the diseases of all our organs.

It is evident from the most cursory review of the diseases of the sanguiferous and nervous systems, that although those of the latter partake more immediately of the affections of the sanguiferous, than those of the sanguiferous of the affections of the nervous system, the effects of derangement of the latter on the former system are more numerous, obscure, and difficult of treatment; the cause of both of which may easily be perceived, on comparing the results arrived at in my Inquiry into the general Laws of our Frame. The circulation, we have always known, is immediately necessary to the functions of the brain and spinal marrow; while it appears from the experi-

ments which have been referred to, that those of the heart and blood-vessels may continue for a certain length of time after the former organs have ceased to exist; having on them only an indirect, but an exceedingly complicated dependence, through the functions of respiration, assimilation, secretion, and excretion.

CHAPTER I.

ON THE DISEASES OF THE SANGUIFEROUS SYSTEM.

Of the diseases of the sanguiferous system there are some in which the force of the circulation is diminished, so that the supply of blood to the parts particularly affected fails, producing various symptoms according to the degree in which this takes place, and the nature of the organs chiefly influenced by it; and others in which the vessels of certain parts are distended with more than their due proportion of blood, either in consequence of the increased action of the heart and larger arteries, or of the vessels of the part being so far weakened that their power of resistance is not in due proportion to the usual force of the circulation. The two last states produce nearly the same train of symptoms, except that the former is preceded by the symptoms of a morbidly increased impetus of the blood throughout the system; but no diseases can differ more than those which depend on the seat of the distention. These last are the diseases of the sanguiferous system, which here chiefly demand attention, both from their importance, and their being those most immediately connected with the results of the preceding investigation, namely, inflammation, and what is called by medical writers, congestion. To these, therefore, I beg leave to direct the reader's attention. I shall in the present publication enter only on those diseases,

the treatment of which is essentially influenced by the facts ascertained by the investigation on the results of which this volume is founded.

Section I.

On Inflammation.

Inflammation may be regarded as the most important of all diseases, whether we look to its frequency, its severity, its relations, or its consequences. In its more chronic forms, it is the precursor of gradual disorganisation; in its acute forms, of those species of disorganisation which are most rapidly fatal. Its relation to other diseases is the most extensive, and its influence on their course the most important — a position illustrated by many of the diseases to which I shall have occasion to refer; for, in a large proportion of our most formidable deviations from a state of health, the obstinacy and danger are proportioned to the degree in which they are complicated with it, which it is not difficult to understand, when we find it produced by all causes of irritation, and itself the most powerful of all those causes.

It thus becomes a point of the last importance to understand its nature, that we may not only clearly perceive the principles of its treatment, but when to expect and how to obviate its first beginnings; for, evident as it is in its active, in its more chronic forms there is no disease more insidious.

In the preceding part I have considered at length the nature of those powers on which the circulation depends. The conclusions there arrived at must be

kept in view, in considering the nature of inflammation.

Exp. 1. There is no difficulty, with the aid of the microscope, in perceiving the first step towards a state of inflammation. It is well known that exposure to the air alone is sufficient to produce inflammation in the internal membranes of warm-blooded animals. This is also the case in the fins of some kinds of fish. The lampern was the fish I employed, and in the warm-blooded animal I employed the mesentery of the rabbit.

On bringing either of these membranes before the microscope, we see a network of vessels, too minute to be perceived by the naked eye, many capable of transmitting the globules of blood only one by one where they follow each other in rapid succession. After the part has remained exposed to the air for some time, the globules begin to move through these vessels with less rapidity; and in proportion as this happens, we perceive the diameter of the vessels enlarging, till that which could admit of only one red globule at a time, now admits of several. As the motion of the globules languishes, and their number increases, their colour becomes conspicuous, which it is not while they pass in smaller number and with greater rapidity. At the same time that these changes take place, we find the number of vessels, capable of transmitting red globules, greatly increased, so that the vessels which, in the healthy state, transmitted only the colourless, are now so much distended as to admit the grosser parts of the blood. From these two causes the part assumes a redder appearance than natural, and also acquires a greater bulk; and the latter seems further increased by the

distention of vessels still too small to transmit the red globules, for the interstices of the red vessels are now more opaque than before the morbid distention took place, without the appearance of extravasation of any kind.

While these changes, which may be distinctly seen with the assistance of the microscope, are going on, the part to the naked eye becomes inflamed, more opaque, and thicker.*

Such then are the changes which take place in the commencement and progress of inflammation. The blood in the capillaries begins to move more slowly; these vessels in the same proportion suffering a degree of morbid distention: and this often goes on till they, by many times, exceed the healthy diameter, and the blood in the most distended vessels ceases to move altogether; and the pain of inflammation arising from the effect on the nerves of this morbid distention is greater or less in proportion to the rapidity with which it takes place. Hence where the distention is effected very slowly, as in chronic inflammation, there is often no pain even in parts of the greatest sensibility.

The only diagnostic symptom of chronic internal inflammation is tenderness on pressure; so that the patient is not aware of its existence till it is thus pointed out by his medical attendant.

The motion of the blood in the capillaries the reader has seen proved, by direct experiment, to depend on the action of these vessels themselves.

* Some of the experiments by which the facts relating to the nature of inflammation were ascertained, were made while I was a student at Edinburgh, and have been frequently repeated since, with the same results, both by myself and others.

When it fails, therefore, we necessarily infer that their power is failing in the same proportion; and this inference is confirmed by their suffering themselves to be morbidly distended by the usual impulse of the blood. It signifies not, as I found by direct experiment, by what means the power of the capillaries is impaired*, whether by mechanical or chemical injury, whether by a cause operating slowly or suddenly. Any cause impairing their power produces the same effects, the severity of the symptoms being proportioned to the rapidity with which the distention is effected, causing the disease to incline more or less to the symptoms of acute or chronic inflammation.

During the foregoing changes in the capillary vessels, the larger vessels of the part, which are too opaque to permit the motion of the blood to be seen in them, suffer no change that can be detected by the microscope, except that, after the distention of the capillaries has become very great, the vessels immediately preceding them in the course of circulation begin to partake of the distention.

Exp. 2. Thus when the fins of the lampern were first exposed to the air, the inflammation assumed the appearance of a slight blush, in which it was difficult, with the naked eye, to discover any vessels; but, after some time, and in proportion as the smaller vessels suffered distention, vessels of a considerable size were seen by the naked eye creeping through the inflamed parts. Before this change is observed in the larger vessels, the capillaries are distended to

* The means employed were various, but the effects always the same.

many times their natural size, and the blood in those most distended has, generally, ceased to move. This, it is evident, cannot go very far, without the latter vessels wholly losing their vitality, and a total loss of vitality in the part ensuing.

The state of the larger vessels of an inflamed part, in active inflammation, is very different from that of the capillaries, and may be ascertained without the aid of the microscope. The increased pulsation of the larger arteries supplying an inflamed part, sufficiently evinces their increased action: nor is there any difficulty in detecting this increased action. If the hand is applied to the seat of the larger arteries of any external part actively inflamed, they are always found acting with more than the healthy power. On this increased action of the larger arteries of an inflamed part, the throbbing and general appearance of activity in the part depends, and on it is founded the popular opinion that inflammation consists in an increased action of all the vessels of the inflamed part — an opinion adopted without a moment's reflection on what must necessarily be the consequence of such an increased action. The reader will presently see the effect of this generally increased action, and its consequences, exhibited by a very simple experiment. The difference between what is called active and passive inflammation, depends on the degree in which the arteries supplying the blood to the debilitated vessels are excited.

We should, at first view, be inclined to ascribe the increased action of the larger arteries to the impediment opposed to the free transmission of the blood through the debilitated capillaries; and to this it has been ascribed by some who have repeated

my experiments : but the following facts point out that it depends little, if at all, on this cause. The communications of the vessels are so numerous and free, that, as the reader will presently see determined by direct experiment, if the passage of the blood is opposed through one channel, it immediately finds another, without occasioning any apparent change in the state of the debilitated vessels. The degree in which the larger vessels are excited is rather proportioned to the nervous irritation, and consequent pain, occasioned by the state of the distended capillaries, than to the degree and extent of the inflammation; for a slight internal inflammation, where the parts affected sympathise more with other parts, excites the whole sanguiferous system; while external inflammation of greater severity has comparatively less of this effect; and in chronic inflammation, when the vessels have yielded slowly, and, consequently, without much nervous irritation, there is comparatively little increased excitement of the larger vessels of the part, and often, even in internal parts, none at all of the whole system, under which circumstances the inflammation is generally free from pain. From these observations it would appear that it is to the nervous irritation occasioned by the morbid distention of the capillaries that we are chiefly to ascribe the increased action of the larger arteries of the part, and not to the degree of impediment opposed to the passage of the blood through the debilitated capillaries and their consequent distention, which would cause it, in all instances, to be more or less proportionate to that distention.

The reader has seen how immediately the action of the vessels is under the influence of the

nervous system, and, in the first part of this volume, that every part of the brain and spinal marrow are sensible of every change in every, even the minutest vessel, and also that every part of those organs may directly influence every vessel, however minute. The final cause of the increased action of the larger vessels in inflammation is evidently to support the circulation in the debilitated vessels, and excite them to a more vigorous action *; and the most important object of the treatment in active inflammation is to regulate this effort of nature, neither to permit it to be so great as to increase the distention, and consequently the loss of power, of the debilitated vessels, nor to become so languid as no longer to support sufficient motion of the blood in them to prevent stagnation, and the loss of vitality consequent on it.

If the inflammation depend on a debilitated state of the capillaries alone, it follows, that whatever increases the action of these vessels should relieve the inflammatory symptoms. This may be regarded as an *experimentum crucis* on the subject; for if exciting the capillaries of an inflamed part does not relieve all the symptoms of inflammation, whatever share the debility of these vessels may have in producing the disease, the co-operation of some other cause must be necessary. If, on the contrary, we find that as, on the one hand, whatever debilitates the action of the capillaries produces inflammation, so, on the other, whatever increases their action relieves it, nothing more is required to prove that on their debility the disease depends.

* See the Introduction to my Treatise on Symptomatic Fevers, 4th edit. pp. 24. and 25.

Exp. 3. I wetted the inflamed web of a frog's foot with distilled spirits, at the same time, still farther to stimulate the vessels, throwing upon it the concentrated rays of the sun, from the reflector of the microscope. The blood in all the vessels, except in those of the most inflamed part, began to move with greater velocity; and in proportion as this happened, their diameters were diminished, their interstices became less opaque, and the redness of the part was lessened.

Exp. 4. This experiment was repeated on the lampern, with the same result. By gentle friction, and applying distilled spirits, the motion of the blood in the inflamed part was repeatedly accelerated; and in proportion as this happened, the vessels became paler, the deeper red returning as the circulation again became more languid.

Dr. Hastings, in repeating my experiments *, in like manner excited the inflamed capillaries in a frog's foot, by oil of turpentine, and observed the inflammatory symptoms abate in proportion as the capillary vessels lost their increased size, and the motion of the blood was accelerated in them; and he gives an account of a case in the 90th page, in which this process was continued till the inflammation wholly subsided. Both excessive heat and cold, in Dr. Hastings' experiments, produced languid motion of the blood, and dilatation of the capillary vessels, exactly in the same proportion as the part became inflamed. When the inflammation was caused by cold, he saw it yield to a moderate and continued

* See the Introduction to Dr. Hastings' Treatise on the Inflammation of the Mucous Membrane of the Lungs.

application of heat, by which the motion of the blood in these vessels was accelerated, and they were made to resume their natural dimensions. When the inflammation arose from the excessive application of heat, cold produced the same effects. These facts, while they, in a striking manner, confirm the result of the experiments just related, illustrate some of the positions respecting muscular contractility which have been laid before the reader, showing that both cold and heat, the temperature of the body being the mean, like all other agents, act upon it, either as a stimulant or a sedative, according to the degree in which they are applied. Hence appears the futility of at first view a plausible argument, that cold, being the mere abstraction of a stimulant, cannot produce the effects of a stimulant, but must necessarily act as a sedative. Many other instances illustrating this observation will occur to the well-informed reader in such subjects. The application of cold produces as positive a sensation as that of heat, and the increased contraction of the muscular fibres on its application is familiar to all. In a certain degree all agents act as stimulants, in a greater degree as sedatives, the difference between what is called a stimulant and sedative consisting in the former, distilled spirits or heat for example, being more inclined to act as a stimulant; and the latter, tobacco and cold for example, as a sedative: but there is a quantity of tobacco, and a degree of cold, so small as to act as a stimulant, and a quantity of distilled spirits, and a degree of heat, so great as to act as a direct sedative.

It is in vain to say that cold cannot act as a stimulant, being only the effect of the abstraction of a stimulant. Whatever directly produces a stimulant

effect acts of course as a stimulant, whatever be its nature, and will be found to obey all the essential laws of other stimulants; that is, a moderate application of it will excite, an excessive application convert it into a directly debilitating power.

It is evident that the blood cannot be long retained in the debilitated capillaries, and thus, as it were, thrown out of the circulation, without some morbid changes taking place in it. Its vitality must soon cease after its motion is wholly suspended, and the changes to which dead blood is liable begin to take place in it. Dr. Hastings observed, that when the debilitated capillaries were stimulated, the blood which passed from them often contained irregular flocculi, instead of globules, which he compares to the ragged portions separated from the coagulum of arterial blood.*

For the manner in which the various symptoms of inflammation, and means of cure, support the view of the disease afforded by these experiments, the reader is referred to the Introduction to the fourth edition of my Treatise on Symptomatic Fevers.

Nothing can be more simple than the *modus operandi* of the means of cure in inflammation. All the local measures are such as either relieve the vessels from part of the fluid which distends them beyond their natural capacity, or more directly excite them to their healthy action. All the general means are such as influence the impulse of the blood, either reducing it where it is so powerful as still further to distend the debilitated vessels, or increasing it when it becomes too languid to afford the aid necessary for

* Dr. Hastings' Treatise, p. 97.

supporting some motion of the blood in these vessels, and thus preventing gangrene, the effect of its total failure.

It appeared to me that it would tend to throw additional light on what has been said, to subject to the test of direct experiment the principal opinions which have prevailed respecting the nature of inflammation previous to that which referred it to debility of the capillary vessels.* Four only deserve attention : the opinion which supposes this disease to arise from a morbid lentor of the blood clogging the minute vessels; that which ascribes it to what has been termed *error loci*, the grosser parts of the blood getting into vessels too small to transmit them; that which supposes a spasm of the extreme vessels to be its cause; and, lastly, that which refers it to a morbidly-increased action of all the vessels of the inflamed part.

The reader will readily perceive that the principle of the three first doctrines is the same. In all, ob-

* For the origin of this opinion, see my Treatise on Symptomatic Fevers, fourth edition. Mr. John Allen, a gentleman whose abilities are well known to the scientific public, and Dr. Lubbock, first brought it forward in a connected form in the Medical Society of Edinburgh about the year 1790; and although imperfect traces of it, which often contradict each other, may be found of an earlier date, they appear to have been unknown to them, and are not such as can deprive them of the merit of having been the first to give a distinct and connected explanation of the phenomena of the most important disease to which we are liable. Although, as far as I know, they made no experiments for the purpose of confirming their views, their inferences were from the phenomena of the disease itself. We have just seen how amply they are confirmed by direct experiment.

struction in some of the minute vessels is regarded as the cause of inflammation. It is surprising, therefore, that none of the supporters of these opinions thought of trying whether or not obstruction is capable of producing it. Admitting that the vessels are obstructed, it does not follow that an accumulation of blood will take place in the part. The blood may pass off by communicating branches, or the vessels may resist the distending force.

Exp. 5. A small hot wire was suddenly passed through the web of a frog's foot, by which the skin about the hole was shrivelled, and the vessels obstructed, no fluid of any kind being discharged. Here an obstruction was produced, surely more than equal to what takes place in many inflammations of small extent, and yet no symptom of inflammation ensued, every part of the web remaining as pale as before the experiment.* The wound finally closed without any degree of inflammation having supervened.

Exp. 6. In order to ascertain whether inflammation arises from an increased action of all the vessels of the part, it is only necessary to induce such an action, and observe its effects. Having brought the web of a frog's foot before the microscope, I now and then, during some minutes, observed the velocity of the blood, which continued, as far as I could judge, the same. The foot was then wetted with distilled spirits, and in a few seconds the blood in all the vessels was moved with a greatly increased velocity, which, as the web was constantly kept wet with the distilled spirits, continued, as long as I ob-

* Introduction to my Treatise on Symptomatic Fevers.

served it, ten minutes or a quarter of an hour. But during no part of the time could I perceive the slightest symptom of inflammation, either with or without the microscope. The vessels, instead of appearing redder, and more turgid, were, as might be expected from what is said in the first part of this volume of the nature of the circulation in the capillary vessels, evidently paler and smaller than before the application of the distilled spirits. The velocity of the circulation was further increased by throwing on the web the concentrated rays of the sun from the reflector of the microscope, but still with the same effects.

In the preface to the fourth edition of my Treatise on Simple Fever, I have in a cursory way pointed out the manner in which the experiments made with a view to ascertain the nature of inflammation seem to throw light on that of fever, which appears to be only a state of general inflammation, the whole of the capillaries being debilitated, and the whole of the other parts concerned in supporting the circulation morbidly excited in the first stage; the second stage being the necessary effect of this morbid excitement when it has failed to restore activity to the debilitated capillaries, in which in slighter cases it succeeds, and the fever ceases.

In fever, the distention of the capillaries is less than in inflammation, the impulse of the blood tending to distend them being necessarily less effectual in proportion as they are more numerous. Hence the symptoms immediately arising from their distention are in each part comparatively slight; but the general fulness, redness, and increased heat of the

surfaces, and the general failure of the secreting power, sufficiently indicate the presence of a generally distended state of the capillary vessels, and thus the experiments which elucidate the nature of inflammation throw equal light on the nature of fever, and the explanation thus obtained is equally confirmed as in inflammation by every part of the treatment found successful in the disease, as well as by all its phenomena, when the true nature of the circulation, as explained by the experiments referred to in the first part of this volume, is kept in view; for in certain respects, although not to the same extent, the powers of circulation have been mistaken as well as those of the nervous powers, as appears from experiments referred to in the first part of this treatise. We still speak, and inferences have been made from inaccurate experiments, which, at first view, seem to prove that the power of the heart itself is the chief power which in every part supports the circulation. That such an opinion is erroneous might have easily been inferred as soon as it was known that, even in man, the blood in certain parts is sent through two sets of capillary vessels before it returns to the heart.*

Section II.

On Congestion.

When the larger vessels of a part are debilitated, and consequently distended, without previous distention of the capillaries, the disease, which may be termed congestion or partial plethora, is of a nature very

* See my paper on the circulation in the Philosophical Transactions for the year 1831; also Appendix, No. VIII.

different from inflammation. In this case little or no distention of the capillaries takes place, as appears from the part being pale, or only slightly redder than natural. The impulse of the blood, from the debilitated state of the larger vessels, being too weak greatly to distend them, they, in consequence of their continued action more or less being, as proved by facts stated in the first part of this volume, wholly independent of that of the heart, retain their power, and, as long as the larger vessels can afford any supply of blood, preserve the circulation. The reader has seen that they can support the motion of the blood, both in the warm and cold-blooded animal, long after the excitement of the larger vessels has ceased, their elastic power alone remaining. Such appears, from dissection, to be the state of the vessels of the brain in sanguineous apoplexy, while in inflammation the larger vessels are comparatively little distended, the distention, as we have just seen, being then chiefly in the capillaries. It is an observation of writers on inflammation of the brain, that stupor, which arises from the distention of the larger vessels, supervening on delirium in this disease, is a fatal symptom: the cause of which is evident. If, while the capillaries are debilitated, the larger vessels to a considerable degree also lose their power, by which the languid circulation in the debilitated capillaries is sustained, the circulation in the latter must soon wholly fail, and consequently death ensue.

In other parts, as well as in the brain, we constantly observe that the distention of the capillaries is attended with acute symptoms, pain and fever, while that of the larger vessels is generally attended with little of either, being chiefly denoted by more

or less tendency to a failure of function in the organ affected. The cause of this difference appears from those experiments which prove that the sanguiferous and nervous systems sympathise in their extreme parts in a way they are found to do in no other; as must necessarily arise from the capillaries, as the reader has seen, on the one hand, supplying to the nervous power the fluids on which it operates in the functions of assimilation, secretion, and excretion, and, on the other, being that part of the sanguiferous system on which the extremities of the nerves by which, he has also seen, they operate in these functions, are distributed; hence the greater activity of the disease in inflammation than in congestion.

Thus it is that the derangement attending distention of the capillaries cannot arise from that of the larger vessels; for, however debilitated the latter vessels may be, unless the circulation in them fail altogether, in consequence of their elastic as well as muscular power failing, in which case the death of the part soon ensues, the capillaries, as appears from statements founded on direct experiments, which have been laid before the public in the Philosophical Transactions, and my Treatise on the Vital Functions, are still capable of affording a certain supply of fluids to the secreting power conveyed by the nerves.

It has long been observed by physicians, that inflammation of the same organ sometimes excites acute pain and a great degree of fever, and in other cases comparatively little of these symptoms, being chiefly remarkable by the lesion of function it occasions. And this difference has been supposed to depend on the inflammation having its seat sometimes in the membranes and sometimes in the substance of the

organ. Thus inflammation of the brain has been divided into two species—phrenitis and phrenismus; namely, inflammation of the membranes and that of the substance of this organ; that of the lungs into pleurisy, inflammation of their membranes, and peripneumony, of their substance, &c., and the difference of the symptoms in such cases has been supposed to depend on the nature of the parts affected. Numerous dissections, however, have now proved the fallacy of this explanation,—the substance of the organ alone having often been found affected in the most acute, and the membranes alone in the least acute cases.* In the former, that is, the most

* If the reader will consult the 20th Epistle of Morgagni *De Sedibus et Causis Morborum*, particularly the 9th, 33d, 35th, 39th, 41st, 43d, 47th, 49th, and 62d sections of it, and some parts of his 21st Epistle, he will find that the symptoms regarded as peculiar to pleurisy have frequently attended inflammation of the substance of the lungs, and that, when the membranes were not at all affected. When we inspect the bodies of those who die of inflammation of the lungs (says Schroeder, Opusc. Med.), they alone are sometimes found inflamed, although the symptoms of pleurisy had been well marked. Petrus Servius opened three hundred people at Rome, who died with the symptoms of pleurisy, in which the lungs were greatly inflamed, the membranes little or not at all. Tissot met with similar cases; and Diemerbroech says, that in two or three cases, in which there had been no acute pain, and where consequently, according to the common opinion, the substance of the lungs alone should have been found affected, the membranes equally partook of the disease. Burserius observes, that dissections are not wanting to prove that inflammation of the membranes has been present without any pain. Sydenham seems to go so far as to believe the substance of the lungs to be very frequently the seat of pleurisy. And Juncker, in his Conspectus Pathologiæ, observes that pleurisy often passes into peripneumony, by which we may understand that the substance of the lungs was found inflamed where the symptoms had been those of pleurisy; for such

acute cases, I believe the capillaries, in the latter the larger vessels, are often the chief seat of the disease; for the two affections may, according to the nature of the cause and the state of the part affected, be combined in every proportion. I am aware that this will not always be found to be the case, for, we have seen, the capillaries sometimes suffer distention with little or no pain, particularly where the progress of the disease is slow. In general, however, in proportion as the distention is confined to the larger vessels, there is less fever and less pain, and when they alone are affected there is little or none of either; the cause of which is evident from what has been said of the different nature of the functions of the larger and most minute vessels: the only function of the larger vessels being to maintain the motion of the blood; the functions of the capillaries being, in addition to this, to supply that portion of the blood on which the assimilating, secreting, and excreting functions depend; the severity of the symptoms of derangement being here, as is generally the case, proportioned to the variety and importance of the functions deranged.

The immediate cause of fever in all cases, whether

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was the prepossession in favour of this division of inflammation of the chest, that when it was found that the appearances on dissection did not correspond with it, it was supposed that the one form of the disease had passed into the other—an opinion which seems to have been sanctioned even by Haller. Yet we find in some of the oldest writers more correct observations. Hippocrates speaks of pleurisy and peripneumony as affections of nearly, if not altogether, the same parts; and Galen observes that the pain in peripneumony is sometimes acute. Many observations to the same effect might be added from authors of the first authority, both with respect to this disease and other inflammatory affections.

original or symptomatic, as appears from all that has been said of the nature of this disease, consists in debility of the capillary vessels; in the former, of the whole system, and when it arises from local disease, of that of the capillary vessels of the diseased part.

All local diseases producing fever are found to have this effect, exactly in proportion as they cause debility, and consequent distention of the capillary vessels of the parts affected. Dr. Cullen, in his system of nosology, arranges them all under three heads; inflammation, hemorrhagy, and serous discharge. If we examine the symptoms of the two last, we shall find, that unless these diseases are of a mere passive nature, arising from a vessel allowing the blood to escape from it, or extreme relaxation, in which cases they do not excite fever, their symptoms are those of inflammation more or less relieved by discharges, in the one case, the effect of rupture of the vessels, in the other, apparently of distention of their extremities; and it is particularly to be remarked, that it is only in proportion as the symptoms of inflammation prevail, that, in the two last cases, those of fever attend. It seems then, both from observation and direct experiment, to be a law of the animal economy, that debility and consequent distention of the capillary vessels, and this alone of all diseased states, applies to the nervous system such irritation as excites to preternatural action the heart and larger vessels, and that even when this state of the capillaries is only local, if of considerable extent, or in a vital part.

CHAPTER II.

ON THE DISEASES OF THE NERVOUS SYSTEM.

As the functions and sympathies of the nervous, even in the most limited, and still more in the most extended sense of the term, that is, including the sensorial functions, are much more numerous and complicated than those of the circulating system (the diseases of which, most immediately connected with the subjects of this volume, inflammation and congestion, we have just considered), the number and variety of its diseases must in the same proportion be greater; and, as appears from the investigation so frequently referred to in this treatise, its functions are not only more numerous, but, if we look only to those on which life depends, with the exception of the circulation, they are also the most important. Its diseases consequently not only embrace a wider range, but more immediately threaten life; an inference which will be amply confirmed by a review of the statements which form the subject of the present chapter. We have seen all the powers of assimilation, secretion, and excretion immediately dependent on the brain and spinal marrow, and we now know that on their powers depend not only the well-being but the existence of all our organs.

If such be the facts, we cannot be more usefully employed than in an inquiry into the various causes of injury to which this system is exposed, with a

view to guard against or remove them; or, where their injurious effects have taken place, to ascertain the means of correcting them, before the arrival of their necessarily fatal stages.

The present chapter is divided into three sections: the first on the diseases of the brain, the second on the diseases of the spinal marrow, and the last on the diseases of these organs jointly. Those of the brain and spinal marrow, separately, are, like the diseases of the sanguiferous system, most important, but comparatively few and simple — namely, the diseases of those functions only which exclusively belong to each. The diseases of these organs jointly, which comprehend the practical part of the subject in which the physiological errors, treated of in the first part of this volume, have been most injurious, are both numerous and complicated, because they necessarily involve, we shall find, certain modifications of the occasionally diseased states of every organ of our frame. Such we should expect to be the case, from the results which have been stated.

The variety and complication of diseases to which any organ is subject are necessarily proportioned to the variety of its functions, and to the extent and power of its sympathies; that is, the degree in which it partakes of, and tends to produce and to modify, the diseases of other organs.

The diseases of the circulating system, or of the brain or spinal marrow singly, whether original or symptomatic, necessarily consist of derangement of their own peculiar functions, and its necessary consequences; those of the brain and spinal marrow jointly, in which we have seen are lodged the immediate organs of life, directly influenced by, and

influencing every organ of our frame, must suffer from, and influence, the diseases of all other parts, and thus be capable, as we shall find from direct observation to be the case, of exciting certain modifications of almost all their diseases.

Section I.

On the Diseases which originate in the Brain.

We have seen, in considering the nature of the disease termed congestion, that when any organ is oppressed by morbid distention of its larger vessels, the functions peculiar to it, as might have been foretold, are impaired, and when this happens to a great degree, are wholly lost. A similar effect necessarily arises, if a cause existing in the organ itself enfeebles its powers. When this happens to a certain extent in the brain, the disease has very correctly obtained the name of nervous apoplexy.

In the former instance, that is, when the impaired state of the functions of the brain arises from a distended state of its larger vessels, that is, a state of congestion, it, with equal propriety, has obtained the name of sanguineous apoplexy. When it arises from the distended state of the capillary vessels, it is then a case of inflammation, the nature of which has just been pointed out. These diseases, being diseases of the circulation, have already been considered.

1. *On Nervous Apoplexy.*

The means of accurately distinguishing that species of apoplexy which depends on the state of the circu-

lation in the head, from that which depends on the state of the brain itself, and consequently the proper treatment in both, and particularly in the latter, are still among the desiderata of medicine. The object of the author, in the present division of the subject, is, to ascertain how far the inquiry on which this volume is founded throws light on those subjects.

As it appears, as far as I am capable of judging from what has been said, that the leading features of sanguineous apoplexy depend on the fact that the power of the heart and blood-vessels is independent of the nervous system, in consequence of which that of the brain may be overwhelmed by a compressing force without directly producing a fatal effect on the powers of circulation; so I think it will appear, from what I am about to say, that the leading features of nervous apoplexy depend on a fact which we have also seen ascertained by direct experiment, that the power of the heart and blood-vessels, though independent of the nervous system, may be influenced even to its total destruction through this system.

I have, in my Inquiry into the Laws of the Vital Functions, had occasion to make many observations on the different species of apoplexy; I shall here, however, endeavour to present at one view whatever is essential towards a correct view of the form of apoplexy before us, the species of apoplexy termed nervous, that depending on the state of the brain itself, and no farther on that of its vessels than the state of the brain itself causes. I shall, in the first place, consider the consequence of such an impression made on the nervous system as greatly lessens the power of the heart and blood-vessels. If the organisation of the brain be suddenly deranged, as

appears from the results referred to in the first part of this volume, instant debility, we have seen, and if the cause be powerful, a rapid destruction, of all the functions of the system ensues. In proportion as the cause is less violent, a longer period intervenes between the debility occasioned by the first impression of the offending cause, and the ceasing of the functions of life, and consequently of those of the sensorial system also; and when the cause is still slighter, provided it be of a temporary nature, the functions, instead of ceasing, finally, gradually regain their healthy state. Whatever be the result, on the first impression of a powerfully debilitating cause affecting the brain, especially if its operation be sudden, the heart acts more frequently and feebly, and often irregularly, the circulating system suffers a similar loss of power in every part of the body, and the sensibility and other functions of the sensorial system are impaired or otherwise deranged. It appears from what has been said in the first part of this volume, that although the origin of the powers of circulation is wholly independent of the brain and spinal marrow, they are immediately under the influence of those organs.

The sphincters of the rectum and bladder, in states of great nervous debility, do not merely cease to be excited by any voluntary effort as in sanguineous apoplexy for example, but, from the generally impaired excitability of the muscular system, particularly where the cause of the disease is at once sudden and extreme, the power on which the degree of contraction constituting their state of rest depends, is more or less enfeebled, and thus, from the relaxation

of the sphincters, the contents of the cavities to which they belong are apt to escape involuntarily.

This state is, if the offending cause has not been extreme, succeeded by some improvement in the symptoms. The heart and blood-vessels in some degree recover from the shock they received. The former begins to beat with less frequency, and with more force and regularity, and the latter to convey the blood with greater velocity, and in a more uniform stream. In proportion as this change takes place, the various functions, as the author has very frequently observed, improve; but if the offending cause has been severe, the heart soon begins again to beat more languidly, and with its function, all the functions gradually and finally fail. If the injury done to the nervous system be of such a nature as particularly to debilitate the vessels of the injured part, during that interval in which the vigour of the circulation is in some degree restored, the capillary vessels of this part yielding, from the debility induced on them by the offending cause, to the increased impulse of the blood, the symptoms of inflammation are thus added to those more immediately arising from the original injury.

Such appear, from the result of numerous experiments detailed in the Inquiry just referred to, to be the consequences of an injury of the brain or spinal marrow, capable of suddenly, and to a considerable degree, tending to derange their organisation. The reader will perceive, that if the view of the subject just taken be correct, the nervous is a much more complicated disease than the sanguineous apoplexy. In the latter, the powers of the nervous system are

impaired, but those of the sanguiferous system are, in the commencement of the disease, entire, and only become affected through the failure of the functions of respiration, assimilation, secretion, and excretion; the gradual distention of the larger vessels of the brain not being of a nature so suddenly to debilitate the brain as, through it, to affect the organs of circulation. In nervous apoplexy, not only the powers of circulation suffer directly from the injury done to the nervous system, thus producing a combination of diseased states of both systems, but the debility of the heart and blood-vessels has a secondary effect on the nervous system. The action of the brain and spinal marrow farther fail from defective circulation, and a state of these organs, analogous to what takes place in the act of fainting, is superadded to that more immediately produced by the cause of the disease. It is not surprising, therefore, that this species of apoplexy sometimes proves instantly fatal; which sanguineous apoplexy, affecting the powers of circulation, only through the failure of other functions, cannot do, except it exists in such a degree as to produce instantaneous and total insensibility, in consequence of which, respiration, which we have seen is a function of volition, immediately ceases, which seldom, if ever, happens in this case.

From all that has been said, it appears that the principles of treatment are necessarily more complicated in nervous than in sanguineous apoplexy.

In sanguineous apoplexy, we have but two objects in view, — to relieve the brain from pressure, and prevent its recurrence. In nervous apoplexy, while we endeavour to counteract the effects of the of-

tending cause on the brain, it is necessary to support the circulation; the failure of which, to a certain degree, must immediately prove fatal. This ought to be done, however, in such a way as tends least to occasion morbid distention of the vessels of the head, to which the cause of the disease often renders them particularly liable; tending as much through the brain, we have seen, to debilitate the vessels of every part, as the heart itself; to say nothing of the cases in which the more direct effect of the injury is exerted on the vessels of the brain itself, which may produce either sanguineous apoplexy or inflammation of the brain, according as the distention takes place in the larger or smaller vessels. From this view of the subject we may readily understand why, although abstraction of blood may prove fatal in nervous apoplexy, yet much of the stimulant effect is often ill borne.

The simplest cases of nervous apoplexy, and those most nearly approaching to the state of the animals in the experiments above referred to, are cases from mechanical injury of the brain. When a blow on the head fractures the skull, and occasions part of the bone to press on the brain without doing further injury to this organ, the case resembles in its nature the purly sanguineous apoplexy. When the compressing power is removed, if no farther injury has been done to the brain, the apoplectic symptoms disappear; but when the blow has also produced what surgeons call concussion of the brain, the case is only a slighter degree of the state in which the rabbits and frogs were found after the brain had been crushed.

No writer, perhaps, has detailed the symptoms of concussion of the brain with greater correctness than

Mr. Abernethy, in the third part of his Surgical and Physiological Essays. It is impossible not to remark how accurately his account of these symptoms corresponds with the results of the experiments here referred to: — "The whole train of symptoms," he observes, "following a concussion of the brain, may, I think, be properly divided into three stages. The first is, that state of insensibility and derangement of the bodily powers which immediately succeeds the accident. While it lasts, the patient scarcely feels any injury that may be inflicted on him; his breathing is difficult, but in general without stertor, his pulse intermitting, and his extremities cold. But such a state cannot last long; it goes off gradually, and is succeeded by another, which I consider as the second stage of the concussion. In this, the pulse and respiration become better, and, though not regularly performed, are sufficient to maintain life, and to diffuse warmth over the extreme parts of the body. The feeling of the patient is now so far restored, that he is sensible if his skin is pricked, but he lies stupid and inattentive to slight external impressions. As the effects of concussion diminish, he becomes capable of replying to questions put to him in a loud tone of voice, especially when they refer to his chief suffering at the time, as pain in the head, &c.; otherwise he answers incoherently, and as if his attention was occupied by something else. As long as the stupor remains, the inflammation of the brain seems to be moderate; but as the former abates, the latter seldom fails to increase: and this constitutes the third stage, which is the most important in the series of effects proceeding from concussion. These several stages vary considerably in their degree and duration, but

more or less of each will be found to take place in every instance where the brain has been violently shaken."

The chief difference between the symptoms of concussion and nervous apoplexy arising from internal causes, is, that in the latter there is not so uniform a tendency to inflammation; which, in the cases referred to by Mr. Abernethy, (in which we have just seen a double cause is operating,) we have reason to believe causes the capillary vessels debilitated by the blow to suffer morbid distention as soon as a certain vigour of circulation is restored. It is this renewed vigour of circulation after the immediate effect of the blow has subsided, so remarkable in the experiments just referred to, that again gives some energy to the brain, and explains Mr. Abernethy's observation, that the tendency to inflammation comes on as the stupor abates.

In nervous apoplexy, from internal causes, the sensibility is often as much impaired as in the sanguineous apoplexy. When this is the case, the danger is very urgent; but, for the same reason as in concussion of the brain, it frequently is less so, compared with the severity of the other symptoms, because here the sanguiferous, as well as the nervous organs, necessarily suffer. In sanguineous apoplexy, the derangement of function being chiefly felt in the nervous system, the danger is nearly proportioned to the degree of insensibility, which is the measure of pressure affecting the brain; but in the case before us, symptoms of the greatest danger often occur, although the patient is not wholly insensible, and not unfrequently while he is affected with a degree of irritability.

The foregoing symptoms, with the state of the pulse, afford the best means of distinguishing these species of apoplexy. In the sanguineous apoplexy the pulse is strong, regular, and less frequent than natural; the last the effect produced by the diminished frequency of respiration, the consequence of the insensibility, unless other causes of injury exist; for the two forms of apoplexy, the sanguineous and nervous, are not unfrequently combined. The more general the effect of the pressure and the more free from tendency to disease in the brain itself, the more perfectly formed will the symptoms of sanguineous apoplexy be; and the contrary of these conditions indicate more or less admixture of the state we are now considering with that of apoplexy from general pressure alone: even the inequality of the pressure may tend, by irritation of the brain, to have more or less of this effect.

Such are the distinguishing symptoms of well-formed sanguineous and nervous apoplexy: and were these diseases always so formed, it would be easy to distinguish them. But we have to lament that this is by no means the case, as indeed, from what has been said, might *à priori* have been supposed. For it must often happen in apoplexy, from distention of the vessels, that the brain will sustain some further injury than that of mere uniform compression. It is not improbable that the circumstance of the compressing force, as just observed, acting partially, may sometimes alone be sufficient to produce this effect; and powerful causes, injuring the organisation of the brain, must often be of such a nature as at the same time to occasion debility, and consequently more or less distention, of its vessels. To these circumstances,

and to the difficulty of distinguishing apoplexy arising from mere general distention of the vessels from that arising from an extravasation of blood or serum, it appears to me that all the difficulties respecting distinguishing, and prognosticating the event in the different species of this disease, are to be ascribed.

It is the tendency to distention of the vessels of the brain that renders a very stimulating plan of treatment a doubtful practice, even in the most decided cases of nervous apoplexy. Were it not for this, the state of the sanguiferous and nervous systems in these cases would equally call for such a plan. But, as might have been foreseen, the more debilitated the brain is, the more readily it feels the effects of any morbid distention of its vessels. Thus our practice in such cases is confined on all hands. Injury may be done by the free use either of stimulants or evacuants, in consequence of the former tending to increase the oppression, the latter the debility of the brain, more or less of both of which, as appears from what has been said, often attends such cases.

The mode of treatment which has appeared to me the most successful, in cases of a mixed nature, is a gently stimulating plan, combined for the purpose of preventing morbid distention, with medicine moderately determining the fluids to the surface of the body, and keeping the bowels free without occasioning a great discharge from them; with occasional abstractions of blood from the head, when the insensibility seems inclined to increase. It appears from what has been said, that the degree of this symptom

is the best measure of the morbid distention of the vessels of the head, the state of the brain itself being the same, which is to be determined by that of the nervous symptoms.

Profuse sweating not relieving the symptoms, which is a frequent occurrence in severe cases of nervous apoplexy, seems always to indicate great danger; and to arise from a general relaxation of the extreme vessels, caused by the debilitating effect of the disease on the brain. It is analogous to the effect on the capillaries, which is pointed out in my Inquiry, produced by crushing the brain, or the application to this organ of any other powerfully debilitating cause.

In cases arising from injuries of the head, Mr. Abernethy thinks that the great tendency to inflammation altogether forbids the stimulating plan. I have just referred to the circumstance which often makes the indication of cure in this respect different in concussion of the brain and nervous apoplexy arising from internal causes, namely, the greater tendency to inflammation from a morbidly distended state of the capillary vessels of the brain in the former, arising from the local effects of the injury.

The foregoing view of the nature of the different species of apoplexy, not the result of preconceived opinions, but of facts open to the examination of every one who chooses to repeat the experiments, and so strikingly confirmed by the observations of Mr. Abernethy and other writers on the effects of injuries of the brain, may tend, perhaps, to render the practice in this varied disease more determinate. It seems, by affording a more correct view of the nature of the symptoms of the sanguineous and nervous

apoplexy, than could have been obtained without a knowledge of the relation which subsists between the sanguiferous and nervous systems, to point out, with more precision than without such aid could be done, the symptoms essential to each, and consequently the modes of practice suited to the various cases in which they separately occur, or are in various proportions blended together. I have entered no further on these modes of practice than was necessary to point out the general principles on which they are founded.

Inflammation of considerable extent, or of a vital part, the reader has seen, excites increased action of the sanguiferous system. He will more readily understand here, than he would have done in the section on Inflammation, why in certain inflammations the action of the sanguiferous system, instead of being increased in force, is diminished. I have just had occasion to observe, that distention of the vessels of the brain seems often, merely from the action of the distending power being partial, so to injure this organ as to give rise to more or less of the symptoms of nervous apoplexy. A similar injury of the brain, we might *à priori* suppose, must sometimes happen in that species of the distention of the vessels which produces inflammation, that is, distention confined to the capillaries of this organ; so that although in this disease the pulse is often strong, and the heat great, as in most other internal inflammations, it sometimes happens that the heat is but little increased, and the pulse small, frequent, and fluttering, more or less of the debilitating effect having been produced in the brain; the danger, for reasons

just pointed out in speaking of the nature of nervous apoplexy, being very great.

A similar state of the circulation is observed in other inflammations, which occasion very great nervous irritation. Thus in inflammation of the stomach and bowels, the heat is often little increased, and the pulse is feeble; the brain and spinal marrow being so injured by the irritation of the inflamed state of these important organs, as to weaken the action of the heart and blood-vessels, and thus cause a greater or less degree of syncope to be combined with the original disease. I have seen the powers of circulation so enfeebled by violent and extensive inflammation of the alimentary canal, that, within twelve hours after the attack, it was impossible to obtain four ounces of blood, although large veins in both arms and both legs, and one of the temporal arteries, were opened, no blood having been taken previously, and the patient, at the time of the attack, having been strong and in good health. He died within twenty-four hours of the commencement of his disease. On inspecting the body, the whole of the alimentary canal was found inflamed, and there was a small spot on the stomach, of a purple colour, without any other morbid appearance. In all such cases, however, the pulse, though feeble, is still hard. Notwithstanding the debility induced on the sanguiferous system by the effect on the brain and spinal marrow of the extreme irritation of the alimentary canal, still, in consequence of the distention of the capillaries of the inflamed part, the vessels more powerfully than in health embrace their contents, so that some degree of tightness of pulse may still be felt. The peculiar irritation of the nervous system which

attends inflammation, still exciting, throughout the whole sanguiferous system, that effort to support the circulation in the debilitated vessels of the inflamed parts.

We see other causes of powerful nervous irritation producing great debility of the sanguiferous system; throwing a solution of opium or tobacco into the cavity of the abdomen, for example, immediately, that is, before it can be supposed to act through any other channel than the nerves of the part to which the offending cause is applied, enfeebles the power of the heart.

The reader may readily understand, from all that has been said, why inflammation of important organs often, and sometimes very suddenly, proves fatal, without the inflammation running its usual course, the sudden derangement of the nervous system being such as to destroy the powers of circulation. This evidently happened in the case just mentioned. He may also see why the pulse, in such cases, when produced by inflammation, rises after blood-letting, which lessens the offending cause, and consequently the impression it makes on the nervous system, always a favourable symptom, both as indicating a proportional degree of vigour remaining in that system, and relieving the most urgent train of symptoms, which indicates the degree in which the general powers of life are debilitated, and the causes of which tend still further, as we have seen, to debilitate the capillaries.

I believe that in some other cases in which the pulse rises after blood-letting, this effect, as far as it depends on the state of the nervous system, may be explained in the same way. On the same principle also, as far

as I can judge, we must explain the sudden debility, and subsequent loss of power, in the circulating system, which ensues on gangrene of any of the vital organs, or indeed more or less if at all extensive of any part.

2. *On Suspended Animation.*

Suspended animation is the suspension of the sensorial functions from any cause interrupting respiration.

Inflating the lungs under such circumstances acts in two ways. It gives to the blood of the smaller vessels of the lungs some of the arterial properties by which they are excited to action; and acting through the blood of these vessels, it communicates to that of the larger vessels, and of the heart itself, more or less of the same properties, independently of the blood already changed being moved on towards this organ; for M. Le Gallois has shown, that after the circulation has permanently ceased, the blood may be more or less changed, by inflating the lungs, not only in the trunks of the pulmonary veins and the heart itself, but also in the great arteries. By these means the circulation in the lungs is often restored, but it is evident from the experiments, an account of which has appeared in the Philosophical Transactions of London, and in the fourth edition of my Inquiry into the Laws of the Vital System, that the function of these organs must be very imperfect till they receive the due supply of nervous power. Now this cannot happen till the re-established circulation has renewed the vigour of the brain and spinal marrow, for which a considerable time is required. We have reason to

believe, therefore, that could the due degree of this power be restored to the lungs, at the same time that they are exposed to the influence of the air, recovery might, in many cases, be effected, where inflation of the lungs alone fails. See Appendix, No. VIII.

The reader has seen that voltaic electricity can supply the place of the nervous power in the lungs, enabling them perfectly to retain their due structure and perform their functions after the latter is withdrawn. I have therefore, both in the Philosophical Transactions and in a note of some length in the chapter of my Inquiry on the nature of death, proposed that, to the instruments used in the recovery of suffocated persons, an apparatus properly adapted for sending the voltaic influence through the lungs in the direction of their nerves should be added. It would be improper here to employ, for any considerable length of time, a stronger power than experience has taught us can be used without bad effects in health. The power should not, perhaps, in the present state of our knowledge, exceed that of fifteen, or at most twenty-four-by-three inch double plates of zinc and copper *, the fluid being one part of muriatic acid and twenty of water, and the electric power should not be applied, at one time, for more than ten minutes or a quarter of an hour. If not too late to be of service, its good effects will be observed before the expiration of this time. †

* I mention plates of this size, because I have most frequently witnessed their effects; but I have reason to believe that a greater number of much smaller plates will better answer medical purposes.

† See a paper which the Royal Society did me the honour to publish in the Philosophical Transactions for the year 1834, and Appendix, No. IX.

Little advantage is to be expected in the case before us from voltaic electricity applied to any other secreting organ, because the revival of the patient depends little, if at all, on the action of any other. Employed as a general stimulant to the brain and spinal marrow, it may be of use by rousing the dormant powers of the system. They are all capable of being excited through these organs. In this way it can only indirectly assist the lungs, and that chiefly in proportion to the degree in which general circulation is restored. It is probable that, as a general stimulant, a greater power may be used with safety, because it may, with this view, be applied interruptedly.

When we compare together the whole of the foregoing statements respecting the effects of voltaic electricity, and those statements with what is said in the following section, may we not hope that, if in so few years such has been the result of its employment on the principles above laid down, a more extensive experience will still extend the advantages derived from it? I have repeatedly seen its use more successful than any other means in obstinate general debility, in which transmission through the stomach and lungs has still appeared to me the best means of applying it. In certain cases of fever, and, it is probable, in all cases of deficient nervous energy, accompanied with little or no inflammatory tendency, it will be found a powerful means of relief. The indiscriminate way in which it is at present employed must tend to prevent the advantages which a better directed employment of it is calculated to produce. *

* See a paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1827, and Appendix to this volume, No. X.

I shall defer some observations I shall have occasion to make on other diseases of the brain to the third section of this chapter on account of their intimate relation to the diseases to which that section is chiefly devoted.

Section II.

On the Diseases which have their Seat in the Spinal Marrow.

The experiments in which different portions of the spinal marrow were destroyed, appear to throw considerable light on the nature of the diseases of this organ. The reader has seen that the destruction of any part of it not only, as is generally known, renders paralytic, that is, deprives of their only stimulus, the muscles of voluntary motion which correspond to that part, and to all parts of the spinal marrow lying below it *; but, by lessening the supply of nervous power to the great chain of ganglions, influences the state of the thoracic and abdominal viscera and the temperature of the animal, consequences of which we have not hitherto been aware.

Even in early stages of the more severe cases of

* It appears from what has been said, that although both the muscles of voluntary motion corresponding to the part of the spinal marrow destroyed, and those corresponding to all parts below it, cease to move, it is from different causes; the former, because their nervous power is destroyed; the latter, because their nervous is no longer subject to the sensorial power. Whether in the former case the power of the muscles themselves is impaired, will depend on the rapidity with which the offending cause has operated. See Part II. Chapter II. of my Inquiry into the Laws of the Vital Functions.

diseased spine, affections of the stomach and lungs frequently attend, and the patient often complains of a sense of cold. The celebrated Mr. Pott remarks of this disease, "Loss of appetite, a hard dry cough, laborious respiration, &c., appear pretty early, and in such a manner as to demand attention." And in another place he observes, that there is "an unusual sense of coldness of the thighs, not accountable for from the weather." Similar observations are made by every writer on diseased spine. How well they correspond with the results of the experiments above referred to need not be pointed out.

It appears from the experiment in which the spinal marrow was simply divided, compared with the experiments in which portions of it were destroyed, that we may judge of the extent of the injury done to this organ, in diseases of the spine, by the state of the stomach and lungs. Anything which so affects the spinal marrow as to interrupt the communication between the brain and other parts, will of course prevent the influence of the will from reaching them, however small a part of the spinal marrow may be injured. But if a considerable part is injured, along with loss of power in the limbs, the patient will experience symptoms of indigestion and oppressed breathing proportioned to the importance and extent of the part the function of which is destroyed.

From what is said of Asthma and Indigestion in my treatise on the latter disease, the reader will see reason to believe, that the foregoing symptoms, namely, those indicating affections of the stomach and lungs in disease of the spinal marrow, may be relieved by the use of voltaic electricity. This observation in the earlier editions of my Inquiry into

the Laws of the Vital Functions, induced the late Mr. Earle to try its effects in such cases at St. Bartholomew's Hospital. I attended in order to regulate the first applications of it, and to point out such precautionary means as are necessary in its employment. He was so good as to address to me the following letter, detailing the results: —

"George Street, August 14. 1822.

"My dear Sir,

"I have much pleasure in transmitting to you the following account of the trials made with voltaic electricity at St. Bartholomew's Hospital. The first case is that in which you witnessed its first application.

"Elizabeth Pepperall, aged seventeen, of fair complexion and light hair, was admitted into St. Bartholomew's Hospital, in August, 1821, in consequence of an affection of the spine, which had existed for about a year and a half. At the time of her admission, it appeared that almost all the dorsal and lumbar vertebræ were affected. She had nearly lost all power over her lower extremities and pelvic viscera; and she complained of very severe cramps at the pit of the stomach, and acute pain in the course of the costal nerves, which was much increased by pressure on the ribs, or any attempt at a deep inspiration. Her general health was much deranged; her pulse was very rapid, with, occasionally, severe palpitation of the heart, and constant dyspnœa. Her digestive powers were greatly impaired; she had no appetite, and could only digest a small portion of stale bread,

and some milk and water. Even this meal was always followed by uneasy sensations at her stomach, and an increase of headache, from which she was hardly ever free. Her bowels were obstinately costive, and the urine was scanty, and deposited large quantities of lithate of ammonia.

"She was placed on one of my invalid beds, which enabled her to remain in a state of uninterrupted rest; and, after the repeated application of leeches, issues were made on either side of the dorsal spine, and subsequently in the lumbar region. The issues were kept actively open, and the strictest attention was paid to her general health. The spine very gradually became less sensible, and the power over the pelvic viscera and lower extremities slowly returned; still, however, her stomach was incapable of digesting any other food than bread and milk and water, her headache remained nearly unabated, and her breathing was habitually difficult. She was in this state when you saw her, and the galvanism was first administered (December 19).

"A trough containing plates of about three inches was employed. The positive wire was applied to the nape of the neck, the negative a little below the pit of the stomach. No sensation was at first produced by twenty plates; but after the sensation was excited, she could not endure more than twelve. The first sensation she experienced, caused her to take involuntarily a sudden and deep inspiration. The galvanism was applied for about a quarter of an hour, at the end of which time her breathing became much freer than it had been for many months. Of this she repeatedly expressed herself perfectly certain, at the same time she felt considerable uneasiness at the

stomach. She was slightly hysterical, in consequence of the agitation she had experienced, but her breathing was tranquil during the whole evening.

"With a view to remove the tenderness in the epigastrium, leeches were applied to the region of the stomach, and the whole plan of treatment adapted to the second stage of indigestion was resorted to. When the tenderness had somewhat abated, the galvanism was repeated with more decided relief to the breathing, and without causing much uneasiness at the stomach.

"After several applications of it, the relief she experienced in her breathing lasted for two or three days, and at length it was only necessary to repeat it occasionally. The effect of its administration was uniformly the same; a most sensible and speedy relief from a state of anxious breathing to perfect ease and repose. Its beneficial effects were not, however, confined to the respiration; the powers of her stomach greatly improved, and she was able to digest a small quantity of meat, or the yolk of an egg, without pain. As her stomach improved, she lost the distressing headache, which had so constantly attended as at one time to lead me to apprehend the existence of disease in the brain, having met with other cases in which scrofulous affection had existed in the brain and spine at the same time. Her progress from this time was uniform, and far more rapid than it had been before; and in about two months, the catamenia, which had been suspended from the commencement of the disease, returned.

"The patient was sufficiently recovered to leave the hospital and return to her friends at Dartmouth early in July, at which time she was able to walk

with very little assistance, and without experiencing the least pain in her back. On reviewing the circumstances of this case, I have not the least hesitation in stating my decided opinion of the great benefit which was derived from the employment of galvanism, not only in affording temporary relief to the breathing, but in improving the secretions, and thus materially contributing to the ultimate recovery of the patient. I feel particularly happy that the patient was in a public hospital, and that the means were employed in the presence of many intelligent medical friends and pupils, who were all equally satisfied with myself of the essential and permanent benefit which she derived from the administration of galvanism.

" It was employed in two other similar cases in the same hospital, those of Ann Baillies and Maria May, in which it produced similar good effects, except that, in one of these, the improvement of the general health, although not less than in the other cases, did not appear to have the same beneficial effect on the disease of the spine. It was tried in another case of spine disease, which was attended with fits of spasmodic asthma. These, as I was taught to expect from the observations you have published on this subject, it failed to relieve. It is remarkable that in the case of Ann Baillies, in which the pulse was from 140 to 150, and very weak, the use of galvanism always rendered it stronger, and brought it down from thirty to forty beats in the minute.

" From observing the good effects of galvanism on the secretions of the stomach, I was induced to make a trial of it in a case of deafness, accompanied with a

total want of secretion of cerumen in the right ear. Its first application produced a watery secretion, which by perseverance gradually assumed the taste and all the other characters of cerumen. The hearing was greatly improved in both ears; but how far this was to be ascribed to the restoration of the secretion is rendered doubtful, in consequence of a tumour having at the same time been removed from the tympanum of the left ear by the repeated application of caustic.

"The foregoing facts you are perfectly welcome to make any use of, should you think them deserving of notice; and I am,

My dear Sir,

Very sincerely yours,

HENRY EARLE."

It appears from the preceding statement, that in disease of the spinal marrow, voltaic electricity is not only capable of performing the office of the diseased part of this organ, by which the vital functions are restored to a state of health, and the patient's sufferings greatly mitigated; but that it also, as might *à priori* be expected, by thus improving the general health, indirectly contributes to the cure of the spinal disease. In one of the cases mentioned by Mr. Earle, it failed to relieve the spinal disease, this being of such a nature, which must occasionally happen, as not to be influenced by the improvement of the general health. With regard to the last case mentioned by Mr. Earle, in which the secretion of cerumen was restored by voltaic electricity, this, it is evident from what has been said, can only happen

when the fault consists in a defect of nervous influence, and not in a diseased state of the vessels.

Section III.

On the Diseases which have their Seat in the Brain and Spinal Marrow.

Introduction.*

The present section, from the number, variety, and complicated nature of the diseases it embraces, must be regarded as the most important division of the practical department of this volume. It is also that, as might be expected, to which the results of the preceding investigation most extensively apply, and was for the first time, but in a more concise form, laid before the public in the last, the fourth edition of my Inquiry into the Laws of the Vital Functions, published in 1839. In the present volume I have entered more fully both into the most essential part of the practical department of the subject, and into the physiological positions on which it is founded, than in any other of my publications. After the publication of the third edition, above twelve years ago, although the work had long been out of print, I deferred publishing any other edition, the additions made with a view to complete the Inquiry having in the interval appeared in eight papers published in the Philosophical Transactions of London. Even at the

* Had not this publication been addressed to the profession as well as the public I should have omitted the following Introduction; but in consequence of its being addressed to the public, I have endeavoured to make the language so simple that I hope it may be equally intelligible to both.

time of the publication of this edition, I had so indistinct a view of the subject of the present section, that I judged it better not to enter on it. It was in the course of the composition of the papers just referred to, with the continued opportunities of comparing the results of experiment with the phenomena of disease, that many of the bearings of the subject presented themselves to me; and it was from having found that they explain practical observations which in the course of these and many previous years had obtruded themselves on my attention, and led to a more successful treatment of a class of diseases both extensive and of very frequent occurrence, that, in the last, the fourth, edition of my Inquiry, they were, although still in a comparatively defective form, presented to the reader, in 1839. Thus the inferences from actual practice and physiological experiment have mutually assisted each other in arriving at the results, and, consequently, have each tended to confirm the inferences from the other; inferences here stated with the more confidence, as many of my professional brethren have now, from witnessing the effects of their practical application, more or less, though none I believe in all respects, adopted the plans of treatment I am about to point out, and, as far as they have adopted them, confirmed the results of my experience by their own.

It appears from the facts referred to in the preceding part of this volume, that while the powers of the nervous system properly so called perform but one, and that a subordinate function, in the sensitive system, namely, as appears from what is said in the first part of this volume, that of affording the means of conveying to the muscles of voluntary motion the

dictates of the will; in those of the vital system they supply the leading power, that to which, if we except the principle of vitality itself, all its other powers are subordinate; yet it is in this system, we have seen, that the powers of the brain and spinal marrow, and of the nerves by which their influence is conveyed, have been overlooked, or seen but in such irregular glimpses, as made no general impression on our doctrines, and left our practical inferences unaided by a knowledge of the functions of those organs from which alone originate the leading power in the vital system.* Even in the present advanced state of our profession, and in one of the first medical schools of Europe, Dr. Alison, professor of the Institutes of Medicine in the University of Edinburgh, a man of talents, and of course of the most extensive knowledge of our profession, it appears from the quotation given in the first part of this volume, in one of his latest works, published in 1834, regards the brain and spinal marrow, on which it appears from what has been said the whole of the functions of assimilation, secretion, and excretion, and on which alone, not only our health, but our actual existence, immediately depend, as having nothing to do in any of those processes, or, as he expresses it, "that these processes are independent of any influence or energy necessarily derived from the nervous system." Can we be surprised, then, that many diseases having their immediate origin in the organs of this power should in their precursory stages be obscure?—an evil greatly increased, we shall find, by the little sensibility of some other vital organs which are ill

* Philosophical Transactions for 1836.

supplied with nerves of sensation: and yet it is but justice towards Dr. Alison to state that his observations are consistent with the general opinion even in the present advanced state of our medical knowledge.

Such, it will appear from the facts I am about to state, is the frequent cause of changes (which, when we are aware of them at an early period, may with certainty be obviated,) being allowed to proceed till they often, always indeed if the disease has arrived at a certain point, produce effects which defy all our means.

In another respect, also, the same field in the practical department of our profession has been encumbered by a cause of a different nature.

As we have seen in the first part of this volume that no serious attempt had been made to draw a correct line of distinction between the functions of the sensorial and nervous powers, from which the practical department of our profession has suffered; in like manner there had been no serious attempt to draw the line of distinction between the powers of which the animal body partakes in common with inanimate nature, and those powers which are peculiar to itself; and it is of no small consequence, we shall find, in our practical inferences, that it appears from the facts which have been laid before the reader, that while, of the four independent powers possessed by the more perfect animals, the sensorial and muscular powers, and the powers of the living blood, are peculiar to the living animal, the nervous power properly so called, the leading power in the vital functions, is in its general nature identical with one of those powers which operate in inanimate nature;

it having been proved, as appears from what is said in the first part of this volume, that this power does not exclusively exist in any particular organisation belonging to the living animal, and that all its functions can be effected by voltaic electricity, made to operate under the same circumstances under which it operates.

Such, indeed, has been the confusion which has prevailed on this part of the subject, that the nervous power and vital principle have been confounded and regarded as one and the same, an error from which even Hunter is not exempt; although, of so different a nature are these powers, that the latter has no existence except in the living animal, while of the former, it appears from the facts which have been stated, it partakes in common with every part of inanimate nature.

The vital principle belongs exclusively to no particular set of organs, but equally animates all living parts, the organs of the sensorial and muscular powers and the blood, as well as those of the nervous power properly so called. Is not the vital principle that which bestows on all living parts the properties which distinguish them from inanimate matter; while the nervous influence is an agent collected and applied only by a certain set of those parts, for the preparation of which both their own peculiar properties and their endowment with that principle are equally indispensable? How confused, then, have been our views of the animal economy, when such a physiologist as Hunter could have confounded with the general vivifying principle an agent, the existence of which in the living animal depends exclusively on one particular set of its organs, and is itself of a

similar nature with one of those powers of which the living animal partakes in common with inanimate nature! The vital principle might, even with more propriety, have been confounded with the sensorial or muscular power, or the vital properties of the living blood; for, wholly different as the properties of these powers are from those of the vital principle properly so called, they, at least, are powers which belong exclusively to the living animal.

The truth is, that the nervous influence, having never been seriously made the subject of experiment, has been regarded as of so mysterious a nature, that it has been open to any fanciful opinions ascribed to it.

If there be any truth in the experiments publicly repeated both in London * and Paris †, and that on a

* See the Philosophical Transactions, and the Journals of the Royal Institution, both for the year 1822.

† De l'Influence du Système Nerveux sur la Digestion Stomacale; par MM. Breschet, D.M.P., Chef de Travaux Anatomiques de la Faculté de Médecine de Paris, etc.; H. Milne-Edwards, D.M.P.; et Vavasseur, D.M.P. (Mémoire lu à la Société Philomatique, le 2d Août, 1823.) Extrait des *Archives Générales de Médecine*, Août, 1823.

We have reason to believe, from many facts recapitulated in my paper published in the Philosophical Transactions of London for 1836, that the ganglionic nerves possess no power of bestowing sensibility on the parts to which they are supplied, and consequently that those parts derive their sensibility from the same class of nerves which bestow it on other parts; nerves belonging to this class accompanying and being bound up in the same sheath with those proceeding from the ganglions and plexuses.

At first view the prevalent opinion appeared to me probable, that in those instances where the ganglionic nerves excite the muscular fibre, they, in like manner, were bound up with the same class of nerves which excite the muscles of voluntary motion. But it appears, from what is said in the first part of this volume, that there are several circumstances which point out, and others which

great variety of animals, with the same results, the nervous influence properly so called, that is, in contradistinction to the sensorial powers, is, of all the

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prove, that the ganglionic nerves themselves possess the power of exciting the muscular fibre. In the organs supplied by the ganglionic nerves, it is not excited in the same way as in the muscles of voluntary motion; the excitement of the muscles of involuntary motion neither being under the influence of the will, nor to the same extent being capable of being produced, as in the case of the muscles of voluntary motion, by mechanically stimulating the nerves either of the living or newly-dead animal — a fact which we have seen misled Haller in his inference respecting the relation which the nervous system bears to the muscles of involuntary motion. But the facts which leave no room to doubt that the ganglionic nerves possess the power, under certain circumstances, of exciting the muscular fibre, are, that the muscles of involuntary motion, although they cannot to the same extent be excited by stimulants applied to their nerves, either in the living or newly-dead animal, can in both be excited by stimulants applied to any part of either the brain or spinal marrow; while the muscles of voluntary motion only obey stimulants applied to the particular parts of those organs from which their nerves arise; and while the muscles of involuntary motion are more powerfully excited by chemical than mechanical stimulants applied to the brain or spinal marrow, the former of which applied to those parts of the brain or spinal marrow from which their nerves arise, if we except electricity, with respect to which their nerves probably act merely as conductors, have little effect in exciting the muscles of voluntary motion.

We know from direct experiment, that notwithstanding the essential difference in the nature of the influence which excites the muscles of voluntary and involuntary motion, the influence conveyed by the ganglionic nerves is of the same general nature with that conveyed by other nerves of motion, although wholly of a different nature from that conveyed by the nerves of sensation. (See Philosophical Transactions for 1836, and Appendix, No. XII.) The most ready test, as I have elsewhere pointed out, by which we may determine whether any particular function depends on the ganglionic nerves, where the parts are too minute for the labours of the anatomist, is its being subject to all parts of the brain and spinal marrow, these being the only nerves which convey the in-

powers of our frame, that which is now best defined, and with which we are most familiar.

The positions which are determined, by the experiments here referred to, are, that besides the nerves of sensation and motion, there is a third set, the functions of which have not been understood, but which differ both in their origins and functions almost as much from both these classes of nerves as these do from each other; namely, the ganglionic nerves. The function of these nerves, we have seen, instead of that of conveying a nervous influence prepared by the ganglions and plexuses, which are wholly incapable of forming any, is to combine and convey the influence of organs distributed through every part of the brain and spinal marrow, and bestow this combined influence on all vital organs, to certain functions of which, namely, the functions of assimilation, secretion, and excretion, this combined influence is necessary.

It is not employed for the excitement of the heart and vessels in the ordinary states of the circulation. For this purpose the blood itself is the only stimulus required.

Although the muscular power, we have seen, is derived from the mechanism of the muscular fibre itself, in the heart and vessels as well as in all other organs to which it belongs; in the organs of involuntary motion its excitement, as far as it depends on

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fluence of all parts of those organs, and that to each individual part, we have seen in the first part of this volume, however minute. It was thus that in my papers published in the Philosophical Transactions of London, the blood-vessels were proved to be supplied by ganglionic nerves, even to their minutest ramifications.

the nerves, is always the effect of this combined influence alone.*

Thus it is, as appears from facts detailed in the first part of this volume, that the nervous influence properly so called, and constituting the leading power in the vital system, requires for its formation organs distributed through every part of the brain and spinal marrow, the powers of which are combined and duly applied by the ganglionic system to all vital organs; to which powers all the other powers of the vital system are subordinate, for they hold under their dominion every part concerned in its functions, whether it derives its power from another source or from these powers themselves; on which depend the formation and well-being of all our organs: and we cannot help observing with what care nature protects both the organs by which the nervous influence is prepared, and those which convey it. The brain and spinal marrow are in all their parts defended by powerful bones; and the trunks of the ganglionic nerves, in every instance, placed so deeply in the softer parts of our frame, as to be almost as well defended as if they also had been secured by bony cases.

We are now to inquire into the nature of the morbid states of the influence conveyed by the ganglionic nerves, with a view to the improvement of the practical department of our profession; for it is impossible to conceive that a knowledge of, as far as life is concerned, the most important functions of the brain and spinal marrow, and of the only functions

* See first part of this volume.

of the ganglionic nerves,—functions of no less importance, those of combining and conveying the influence of the vital organs of the brain and spinal marrow,—should not essentially influence that department; that the state of the leading power of the vital system should not be essentially concerned in its diseases.

As the nervous influence is one of those powers, we have seen, which operate in inanimate nature, it cannot itself, strictly speaking, as I have already had occasion to remark, be the subject of disease; but the organs which supply, and those which convey it, are as much so as other parts of our frame, and its effects must be regulated by the state of those organs.

Certain stages of their diseased states are familiar to every practical physician. But as we have neither been aware that the brain and spinal marrow supply, and the ganglionic nerves combine and convey, the powers by which the immediate functions of life are directly performed, namely, those by which our food is converted into the various organs of our bodies, and their state of healthy vigour maintained *, our knowledge of the nature and immediate cause of many of those diseases has been extremely imperfect. From this defect of knowledge, and the want of sensibility in the parts concerned †, their early stages

* See first part of this volume.

† Neither the brain nor spinal marrow appears to possess any sensibility. Previous to our being aware of the distinction between the nerves of sensation and those of motion, certain parts of them appeared to possess sensibility, because the muscles of voluntary motion are thrown into contraction by irritating those parts. This, we now know, does not necessarily imply that those parts are endowed with sensibility. It is also a fact that many of the other vital organs

often excite little attention; and it not unfrequently happens that no serious attempt is made to arrest their progress, in their curable stages.

Nothing can be more evident than the inference, that if the organs of the leading power in the maintenance of the functions on which the healthy structure of every part depends be distributed through every part of the brain and spinal marrow, those functions must be influenced by all causes which tend to impair the vigour of either, or any considerable portion of either of these organs; and no fact, we shall find, can be more notorious than that, in many of those instances where the nervous system has long suffered under causes of irritation, the powers of the organs which alone supply the nervous power properly so called at length suffer, more or less, some diminution of power, which cannot take place without more or less producing some diminution of the powers most essential to the maintenance of life, and, when considerable, must endanger, and at length destroy them; and under such circumstances, accordingly, we find derangement of function in some organ essential to life is often at length established, which frequently resists the means at present usually employed, and terminates in a fatal derangement of

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are ill supplied with nerves of sensation — the lungs, the heart, the liver, &c. These causes have greatly contributed to the obscurity of the diseases depending on a failure or irregular supply of the influence conveyed by the vital nerves. This may, at first view, appear to be a defect in the constitution of our bodies; but it is probably the cause of much less inconvenience than would have arisen from a high degree of sensibility in organs the functions of which are constant, and subject to frequent, and often sudden, causes of excitement.

structure; while in the earlier stages, from the insensibility of many of the vital organs, the patient's state appears to differ but little from that of others who are what is called nervous, and sometimes continue so, particularly if the nervous symptoms are only occasional, for a long life, without any symptoms of danger supervening in them, no permanent irritation of nerves having taken place.

It is evident that these cases, however similar in their symptoms, must be of an essentially different nature, which arises from the intervals of comparative health constantly allowing the organs concerned to recover their power in the latter cases; in which, however, we find, if any additional cause of nervous fret arises, of sufficient power to render the nervous fret permanent, the case by degrees in a short time assumes the permanent form of the preceding one, and in all respects is a case of the same nature; and so much more distressing it soon becomes than in its preceding state, that the patient often refers the whole to the cause which has thus aggravated the symptoms; and the original source of the disease is wholly obscured.

The nature of the difference will be evident if we compare them with the facts above detailed, and which are recapitulated in my paper on the Powers of Life, published in the Philosophical Transactions for 1836. In the one case, the derangement has its seat in the central organs of the sensitive system; in which, therefore, however severe the suffering, life is not endangered, because the organs of the sensitive system—with one exception, we have seen, which is not here in question—have no share in maintaining it: in the other, it extends to the vital organs of the brain and

spinal marrow ; and the circumstance of the two cases bearing so near a resemblance arises from the sufferings being in both in the sensitive system ; for the one system, for the reasons stated in the first part of this volume, never suffers without the other more or less partaking of the suffering ; and, all our feelings belonging to the sensitive system, the immediate sufferings are nearly the same, whether the vital organs of the brain and spinal marrow, which are devoid of feeling, partake of the disease or not ; often less in the former case, as might be supposed, when the original disease is in the insensible parts of our frame ; and indeed often continue so, until the greater evil declares itself by the suffering of some other part of the vital system, more or less supplied with nerves of sensation, and the functions of which, consequently, being more evident, are better understood.

The first thing which suggests that the disease may not be wholly confined to the sensitive system, is the functions of this part being more prominently and constantly affected than is common for those of any particular organ to be in what we call nervous complaints.

Even under such circumstances, however, we are not always alarmed ; we have often before seen such affections of the same part arising from causes, the effects of which proved trivial, and which yielded readily to the usual remedies ; and not being aware of the change which has been gradually going on in the vital organs of the brain and spinal marrow, on which the vigour of all other vital parts depends, we see no reason why the derangement of function should not yield as in other cases ; the cough, or the headache, is a little more obstinate than usual, but

we see no reason why the patient should not do well.

In such cases, however, unless we can trace the evil to its source, and remove the cause which is preying on the vital organs of the brain and spinal marrow, we generally find that he does not do well; and are often at length awakened to his real state, by symptoms of change of structure supervening on those of deranged function, when, for the most part, the disease has advanced too far to be arrested.

Of the affections of which the brain and spinal marrow equally partake, there are three forms in which the nature of the disease is essentially different. In the first, the offending cause makes its attack on the central organs of the vital system themselves: in the second, on those of the sensitive system only: in the third, on some other organ of the vital system.

In order to place the nature, progress, and treatment of these diseases in a clear point of view, it is necessary to apply the results stated in the preceding part of this volume, for the purpose of tracing, with more care than has been done, the laws of what in medical language has been termed the sympathy of parts, by which the complicated course of the most important of the diseases of which I now speak is regulated, and on which, consequently, their appropriate treatment must be founded; and also to inquire into the nature of those states which precede the establishment of organic disease, which in the great majority of such cases being the fatal termination, must in the course of the treatment be constantly kept in view.

Although much has been written on the former of these subjects by authors of great name, the meanings

attached to the term sympathy of parts have remained indistinct, and the phenomena arranged under it ill defined; from which it may safely be inferred that we have not been in possession of all the facts on which these phenomena depend. It is necessary, before I enter on the most important of the practical part of the present treatise, to inquire how far my experimental Inquiry, referred to in the preceding parts of this volume, tends to throw light on the nature of what is termed the sympathy of parts.

*Of the Phenomena and Nature of the Sympathy of Parts in the more perfect Animal.**

I shall not detain the reader by observations on what has been done by others on this subject, but immediately, by an appeal to the phenomena, endeavour to place its laws in what appears to me the only correct point of view.

It is not my intention to enter into any more extensive view of the phenomena of sympathy than is necessary to illustrate the principles on which it depends; and still less into all the various phenomena of disease dependent on it, farther than to obtain a distinct view of the nature of the diseases we are about to consider here.

It is necessary, in the first place, clearly to deter-

* The following division of the subject, as well as that which follows it, are chiefly addressed to professional readers. It is difficult to make them sufficiently simple to be readily understood by those unacquainted with the structure of the animal frame. They are only requested to bear in mind the inferences arrived at in these divisions; at the same time I have in both made the language as simple as I could.

mine what we mean by the term sympathy, or, I should rather say, to point out the sense in which I shall employ it, for few terms have been employed with less precision. We do not refer to what is called sympathy all the effects of distant parts on each other, although there are few of these which have not, by some writer or other, been referred to it. I shall not, for example, refer to sympathy the influence on each other of the parts concerned in any act of volition, nor the effects of injury done to the trunk of a nerve on the parts in which it terminates, nor the congestion, throbbing, or other effect, from a cause seated in a part, however distant from the part affected, increasing or obstructing the circulation in it, (obstructed liver, for example, does not produce piles by sympathy,) nor, in short, any instances in which distant parts influence each other, where the structure of our bodies at once points out the channels of communication.

But when a cause, for example, which makes its impression on the stomach, produces palpitation, I shall regard it as affecting the heart by sympathy, because it at once appears from the structure of our bodies that there is no direct channel of communication between, apparently, the only parts concerned.

As it is evident, however, that no part can influence another between which there is not some more or less direct channel of communication, we may be assured that the phenomena of sympathy are produced, as in the case of all other phenomena in which distant parts affect each other, namely, by the propagation of the impression along contiguous parts, the only difference being, that in the one case the channels of communication are evident, in the other

obscure; and this we shall find arises from their being more complicated as well as less readily detected.

The term sympathy, then, may be defined, the influence of distant parts on each other, between which the mere structure of our bodies, compared with the phenomena, does not at once point out the exact channels of communication.

Two systems, the nervous and sanguiferous, with a few comparatively unimportant exceptions, pervade every part of the body. There are no other means of communication among all its parts. As the phenomena of sympathy then, we shall find, extend to all its parts, it must be through one or both of these systems that it operates. We know that it does not operate through the sanguiferous system alone, because many of its causes are such as are incapable of directly impressing this system; and many of its effects such as no unaided affection of this system could produce. It must, therefore, be more or less through the intervention of the nervous system that its phenomena take place; but it will appear that all its phenomena are such as may take place through this system alone. We thus arrive at the conclusion, that the channels of communication here are through the nervous system, a position which has been almost universally admitted; and the phenomena of sympathy have been supposed to depend on the connexion formed by the nerves with each other, in their progress from the central parts of the system to the parts they influence.

The various parts of the living animal, as I have already had occasion to observe, may be divided into

active and passive. The belly of a muscle is the active, the tendon the passive part. In like manner, the brain and spinal marrow are the active, the nerves the passive parts of the nervous system, the latter possessing no power but that which they derive from the former. *

As soon as it was proved that the nerves are only the passive parts of the nervous system, it was evident that their influence on each other could not be the means on which the phenomena of sympathy depend, because these phenomena do not consist in the mere continuation of the impression from which they arise, the sympathetic effect being often of a nature wholly different from the immediate effect of that impression. The cause which excites pain alone in the part on which it operates, may excite motion alone in that sympathetically affected, and *vice versâ*. Some portion of the parts, therefore, through which the impression is communicated, must belong to the class of active parts. It must be capable, on being impressed, of originating an effect of a nature different from that of the cause which impresses it, a function of which, from all our observations on the subject, we know the nerves to be incapable.† It appears, then, that the phenomena of sympathy take place through the active parts of the nervous system, and consequently that they depend on organs which belong to the central parts of that system; a conclusion amply supported by the direct facts, and to which, indeed, by a review of these facts, we are necessarily led.

What particular connection of nerves exists between

* See the Second Part of my Inquiry into the Laws of the Vital System.

† An observation well illustrated by facts stated in the first part of the present volume.

a vital organ and the skin which covers it, between the liver and ligaments of the shoulder, between the intestines and abdominal muscles, the stomach and cartilages of the ribs, &c.? Why does inflammation of the internal membrane of the ribs spread more readily to that part of the membrane of the lungs which is only in contact with it, than to the parts in continuation with it, which are supplied from the same branches both of nerves and blood-vessels? The same question may be asked respecting inflammation of the membranes of the abdomen and of the head; for even the interposition of bone does not prevent this sympathy of neighbouring parts, of which the bone itself partakes. In inflammation of the bowels, we find parts which lie in contact with each other partaking most of the state of each other, although their distance is great, if measured by the course either of their vessels or nerves. That the phenomena of sympathy depend on changes in the central parts of the nervous system, would appear from the fact alone, that feelings continue to be referred to a limb which is lost, at whatever part the separation has taken place. Besides, we know that the nerves convey impressions from all other parts to the central parts of the nervous system, and that the latter parts also through the nerves influence all other parts —facts capable of explaining the phenomena, without any supposed action of the nerves on each other.

Here, in considering the nature and progress of disease, a question arises: Is there a common centre of sympathy? Are the parts whose office it is to influence those secondarily affected, always the same, or are they different in different cases, so that there

is more than one such centre? To answer this question, which we shall find of no small importance in the diseases we are about to consider, it will be necessary briefly to refer to the results arrived at in my papers published in the Philosophical Transactions for 1831, 1833, and 1834, the substance of which has been incorporated with the other statements which form the Second Part of the last edition of my Inquiry into the Laws of the Vital Functions.

In these papers I have had occasion to refer to the sets of experiments, made with a view to draw the line of distinction between the sensorial and nervous functions, and determine the relation these functions bear to each other; from which it appears that the nervous bears the same relation to the sensorial, that the muscular bears to the nervous system. The power of the muscular, it appears from the facts there adduced, is independent of the nervous system, but always in some of its functions, and in all its functions occasionally, under its influence. In like manner, it was found, as appears from what is said in the fourth edition of my Experimental Inquiry, from an extensive set of experiments instituted for the purpose, that the power of the nervous is independent of the sensorial system, all the nervous functions remaining after the final removal of the sensorial power; but that in some of these functions always, and in all of them occasionally, the nervous system is under the influence of that power.

It appears from the results of the investigation, so often referred to in this volume, that there are, in the more perfect animals, two systems in a great degree distinct, respiration being the only function in which the powers of both systems directly co-operate; that

depending on the nervous and muscular powers alone, and that in which the sensorial system is included: the former constituting the vital functions, those by which we are maintained, the latter the sensitive functions, those by which we are connected with the world which surrounds us, and to which we owe all our enjoyments and sufferings; and that both sets of functions are under the immediate influence of the active, that is, the central parts of the nervous system.

It further appears, from the facts referred to in my papers published in the Philosophical Transactions for the years 1833 and 1834, on the Nature of Sleep and Death, and in the fourth edition of my Inquiry into the Laws of the Vital Functions, that it is not with respect to their functions alone that these systems are entitled to be regarded as distinct systems. The parts of the brain and spinal marrow associated with the organs of the sensitive system, and those associated with the organs of the vital system, are, as appears from experiments to which I have frequently referred, distinct sets of organs, having different localities, and obeying different laws. It is quite evident, therefore, that if both the sensitive and vital functions in the various parts of our frame sympathise, which is evidently the case, it cannot be through the same parts of the brain and spinal marrow: as these functions depend on different sets of organs, their centres of sympathy must be different.

It will appear, on the other hand, from the facts I am about to state, that the phenomena of sympathy themselves lead to the same conclusion — that each system possesses its own centre of sympathy, and consequently that there is a centre of sympathy in

a great degree independent of the sensitive system, and therefore of our feelings; on which, we shall find, depends one of the greatest difficulties which beset the practice of medicine, and which has led, and still leads, to errors of an extensively fatal nature, and which it is the chief object of the present section of this treatise to counteract.

The sympathies of the sensitive system necessarily force themselves on our attention. When the feelings of disordered digestion, for example, are accompanied by pain or sensible derangement of function in a distant part, it is impossible for us to overlook the sympathy on which such symptoms depend. But the sympathies of the vital system, often operating unconsciously, are not unfrequently obscure. The vital functions of both the head and chest, for example, are not unfrequently affected by such a state of the digestive organs as does not, by any complaint of the patient, call the attention to the source of the evil; and unless it be so called by other means, if the case be of a serious nature, it necessarily proves fatal; for the consequence cannot be removed while the cause continues to operate.

Another circumstance which has contributed to keep us in the dark respecting such cases is, that the centres of sympathy in the two systems not being identical, the sympathies of the two systems are not, in all instances, most prevalent in the same organs. A vital organ may be an organ of dull feeling, and little capable of influencing other parts of the sensitive system, and yet, as far as relates to the other vital organs, of the most powerful and extensive sympathy; and thus an affection which neither betrays itself to any of the senses, nor implicates organs,

the sympathies of which are, from their sensibility, the most prominent, may be undermining all the powers of life ; and I think all conversant with the practice of medicine will admit that it is here that it is at present most defective. Fatal cases are every day occurring, as appears from dissection after death, the progress of which might have been easily checked, had we been aware of their nature before the secondary and more prominent affection had shown itself; and even after it had appeared and made some progress, had we been aware of the cause which was supporting and aggravating it ; for few affections are, from the first, necessarily of a fatal nature.

There is no organ whose sympathies are absolutely confined either to the sensitive or vital system, — all organs, more or less, partaking of the functions of both : but that the different species of sympathy prevail most in different organs, a thousand phenomena assure us ; and we have ample proof that the vital often so little influence the sensitive sympathies, as neither to attract the attention of the patient nor his medical attendant.

In no other organ perhaps are the sympathies of the sensitive system so powerful as in the stomach — an organ of the most acute sensibility ; but the sympathies of the vital system are much more powerful in the liver, which, although of very dull feeling, influences, and is influenced by, the vital functions of distant parts more powerfully (if we except the brain itself) than any other organ ; and that, it will appear, from what I am about to say, in a degree that admits of no comparison.

This observation is well illustrated by the pheno-

mena of disease in some tropical climates, where the sympathies of our frame are most active. Why do we rarely see any invalid return from the East Indies labouring under any other disease but that of the liver? The diseases of India, as of all other countries, are various; but as most of the diseases of India are too rapid in their progress to admit of the patient coming to this country, it is only those of a chronic nature that we see; and so powerful are the sympathies of the liver in such climates that all cases of continuance are inclined to terminate in affections of this organ, which, acting as a remedy to the preceding disease, particularly when, as is most apt to happen in such climates, disease of structure has supervened, on the patient's arrival in this country his disease is generally found wholly to have centred in the liver.

We are now to premise such observations on the process by which organic disease is established, as are necessary for a clear understanding of the nature and treatment of the diseases we are about to consider. This division of the subject is also chiefly addressed to the professional reader; at the same time I shall still make my language as little professional as I can.

On the Process by which Disease of Structure is established.

It will not be difficult, I think, with the aid of the experiments referred to in the preceding part of this Inquiry, relating to the functions both of the nervous and sanguiferous systems, compared with the well-known laws of the animal economy, to ascertain, up

to the moment at which change of structure begins to take place, when, as in the great majority of cases, it is the effect of evident derangement of function, the process by which it is established.

When we attempt to advance farther, our difficulties are greatly increased; and were we capable of ascertaining the various changes which constitute the different forms of disease of structure, we have so few means of influencing them, that it is probable their treatment would be little improved by this knowledge.

In most instances, on the other hand, we possess means which powerfully influence the states which precede it; and the better these states are understood, the better we shall be enabled to perceive the first tendency to organic change, and regulate the means which tend to prevent it, and thus to prevent diseases which it is often so little in our power to remove, or even much to alleviate.

On the powers of the sensorial, nervous, and muscular systems, and the powers of the living blood, and the relations these powers bear to each other, we have seen in the first part of this volume, all the functions of life, more or less immediately depend; and consequently all but empirical modes of treatment (and these, we have seen, can never with anything like certainty in cases at all complicated be depended upon) must be founded.

The knowledge of particular functions is necessarily of slow growth. It must be the result of many minute and laborious investigations; and although much has been done in this department by able physiologists, it must still be regarded as in its infancy. But however carefully individual functions

may be studied, it is evidently impossible that they can be understood without a knowledge of the general laws to which they are all subjected. This, therefore, in the present state of our profession, is still the first object which demands our attention.

Thus it was that, after the revival of science, the attention of physiologists was in the first instance directed to determine the source and nature of our more prominent powers, and the way in which they influence each other in their various functions.

In the preceding parts of this volume we have seen the difficulties which lay in our way; and it will appear, I think, from what I am about to say, that as far as relates to those acquainted with the structure and laws of our frame, we are now better than at any former period prepared for the task here proposed.

We know from ample experience that all derangement of function tends to derangement of structure; the time required for this effect being different according to the state of the particular constitution, the nature of the part affected, and the nature and degree of the derangement produced in it.

The most frequent causes of derangement of function make their impression on the nerves of the part, and their more immediate effects may be divided into two stages. The first is merely a state of nervous irritation from causes acting on the part itself, or some part with which it sympathises. In neither instance, in this stage, is there any disease in the part to which we refer it. To whatever part the cause of irritation is applied, the immediate cause of suffering is in the central parts of the sensitive system, and is only referred to the part to which we refer it,

in consequence of experience having associated certain feelings with certain parts of our frame.

The suffering of the central parts of the sensitive system does not long continue without the central parts of the vital system properly so called, by the sympathy which exists between all neighbouring parts, partaking of it. Thus the nervous power requisite for the functions of the part impressed by the offending cause at length more or less fails; and, in consequence of this failure, its extreme nerves, on the co-operation of which with its extreme vessels, and the fluids they convey, all its assimilating functions, we have seen, immediately depend, begin to be incapable of their part in these functions. Thus disease of function in the part itself is induced; but this also arises from the state of the central organs; and there is still no farther disease of the part itself than arises from the irritation of the vitiated secretions, in consequence of a more or less impeded supply of nervous influence, on which the vital functions of the part depend.

To a certain point, the vessels accommodate themselves to the change; for the resources against the establishment of disease in every part of the system are powerful. The functions of the part are more or less disordered, for one of the powers on which they depend is more or less enfeebled; but the vessels still maintain the healthy diameter and a free motion of the blood, and for some time there is no evidence of the debilitated state of the nerves, the consequence, through the central organs, of the causes which had been applied to the seat of the disease having spread to them.

The two stages I have now described are thus established; the only difference between them being,

that to the mere nervous irritation constituting the first, the vitiated secretions of the part originally impressed by the offending cause, in consequence of the continuance of this stage, are now added. These may be regarded as the two first stages tending to disease of structure. If the first is not removed, the second, in most cases, will soon supervene; and this stage, namely, the nervous irritation and consequent deranged secretion, seldom lasts very long without bringing the part into the state which immediately precedes disease of structure, unless the particular nature of the part affected obviates this consequence.*

The usual effect of the continuance of that state of the nerves of the part by which the function suffers is, that the debility at length extends to the capillary vessels which supply the fluids on which the influence conveyed by the nerves operates in the functions of assimilation, secretion, and excretion.† Thus, it appears from what has been said that a state of inflammation, either acute or chronic, is established. Under such circumstances, the texture of the blood, we have seen, soon suffers, and the next step affects the structure of the part, sooner or later, according to the nature of the part affected, and according as the inflammatory state is more or less acute.

* As is often the case with respect to the liver in this climate, the function of which will sometimes continue subject to occasional and even permanent derangement for many years, without its structure becoming affected; but I believe there is no other organ to which this observation applies.

† The immediate cause of excretion is the stimulating effect of the excreted fluid itself on its ducts; but that fluid is formed from the blood by the powers of the nervous influence, and to that influence, of course, owes all its properties.

Such is the succession of events when the offending cause tends directly to debilitate the nerves alone. It may, however, act directly on the vessels alone, which only happens in cases of rare occurrence, or on both, this last being the process most frequent in acute, the first in chronic disease; and here, as in all other instances, whether the offending cause acts on the nerves or vessels, or both, instead of directly debilitating, it may in the first instance act as a stimulant, and the first effect on both be that of increased excitement, the debility being only consequent on this effect.

The whole of both processes, as far as relates to the vessels, that is, whether the offending cause acts as a stimulant or direct sedative, may be distinctly seen in the transparent parts of living animals, as I have often witnessed, with the aid of a microscope of moderate power.* While the offending cause acts as a stimulant, its effects, we have seen, are found to be those of lessening the capacity of the capillary vessels, and in the same proportion increasing the velocity of the blood in them; and the inflammatory state only supervenes in proportion as the vessels, exhausted by their increased action, begin to lose their power.

In the one or other of these ways, that is, either by the directly debilitating effect of the offending cause, or in consequence of the morbid excitement produced by that cause, a state of debility, both of the extreme nerves and capillary vessels of the part, is always at length induced by continued causes of irritation. If the cause be such as equally affects the nerves and vessels, the power of both fails together; if chiefly

* Introduction to the Second Part of my Treatise on Febrile Diseases, 4th edition.

the nerves, their power is impaired by the process just described, and their debility, if continued for a sufficient length of time, never fails at length to be communicated to the vessels with which they are associated in all their functions, and which, we have seen proved by direct experiment, are, equally with the nerves themselves, under the influence of the brain and spiral marrow.*

Thus inflammation of the part, of an acute or chronic nature, according to circumstances, is established; and it is evident from what has been said, that the tendency to disease of structure, *cæteris paribus*, must always be proportioned to the degree in which this takes place; that is, in proportion to the derangement of those organs, namely, the extreme nerves and vessels, on the healthy co-operation of which the due structure of every part depends. Hence in chronic as well as acute cases, the degree of tightness of pulse is always found† one of the best measures of the tendency to organic disease; and hence, in its prevention, the great importance of anti-inflammatory measures, as far as the state of the strength will admit of them, and the great injury done by every cause which tends to increase the inflammatory tendency beyond what is essential to the maintenance of the general strength; for the greater the debility, the more intractable all diseases become. The art of medicine ought to be so directed as to second the efforts of nature to restore power to the

* My papers in the Philosophical Transactions for 1815, 1829, 1833, and 1836.

† See the section on Inflammation in the present part of this volume, and also Appendix, No. XIII.

debilitated parts ; and in proportion as her efforts fail, ours must be increased, otherwise both necessarily become in the same degree ineffectual.

The way in which the inflammatory state operates in effecting the various changes which constitute the different species of organic disease, after the point at which we have arrived in tracing the nature of inflammation, namely, that soon after the blood loses all motion in the capillaries, its texture begins to suffer, which may be regarded as the first stage of change of structure, must be the subject of future investigation. In the mean time, the information of most consequence is the nature of the states which incline to change of structure, and the best means of counteracting their tendency ; because, after it has taken place, if we except certain organic affections of the liver, over which the great powers of mercury give us some control, it is seldom in our power essentially to influence its progress.

There is one instance, however, in which the structure of the part suffers, and in which the change is simple, because it consists in the mere destruction of the healthy organisation, not in the establishment of any new organisation of the parts affected, and is evidently but the continuance and consequent increase of the change which has been going on from the commencement of the disease.

We have seen that all the changes which precede organic disease indicate more or less derangement in the vital functions of the part. From an early stage, either its vessels or nerves, or both, are diseased. If the mere failure of power proceeds without the interference of any cause to disturb its course, it is evident that it must terminate simply in a total loss of its vitality,

and thus become subject to the laws of inanimate matter. Such is the termination in gangrene; a change, for evident reasons, which more peculiarly belongs to active, as new organisation, if we except suppuration, to chronic inflammation; because the latter change generally requires a considerable time for its accomplishment.

We thus arrive at a knowledge of the changes which precede change of structure, till the moment at which it is about to take place; when the only change is the gradual loss of all power, and we find no difficulty in tracing all its steps.

Such are the observations which it seemed necessary, in the present state of our profession, to premise before we enter on the consideration of those diseases which originate in general affections of the nervous system, properly so called, of which the brain and spinal marrow are the only active parts — the only organs which supply the influence on which its powers wholly depend: so far from correct is the statement of Dr. Alison, of Edinburgh, above quoted, from his treatise on the present state of our profession. See page 24th of this volume.

1.— *On a debilitated state of the Brain and Spinal Marrow, when the offending cause makes its impression on these Organs themselves.*

As we have seen that on an agent supplied by the brain and spinal marrow alone, the functions of assimilation, secretion, and excretion depend, it necessarily follows that the derangements to which the immediate organs of these functions are subject may

be of two kinds. They may either be the effect of causes acting directly on these organs themselves, or on the organs which supply an agent essential to their functions; and this inference, from all that has been said of the assimilating, secreting, and excreting functions, we shall find amply confirmed by the nature, the course, and consequences of their derangements.

As all discussions are the clearer the more definite they can be made, it is the most distinct plan to consider, in the first place, the derangement of one particular organ, or set of organs; and when the principles are illustrated by the phenomena which attend and are consequent on them, their application to all other cases of the same kind will be easy; and I shall make choice of the digestive organs, both as the organs of the most powerful and extensive sympathies, and those the functions of which are most easily made the subject of observation.

In conformity with the results of the experiments above referred to, we find that all diseases affecting any considerable portion either of the brain or spinal marrow, more or less derange the assimilating functions; and from the greater sensibility and more evident functions of the digestive organs the effect is generally first, and to the greatest degree, perceived in them. Even a piece of bad news may instantaneously, either by its direct effect on the nerves of the stomach, or by producing a vitiated secretion of gastric juice, destroy the appetite; for mental causes, of a serious and permanent nature, sensibly derange the assimilating functions in every part of the frame; and we find similar effects from diseases or accidents affecting any considerable portion either of the brain or spinal marrow. These consequences are as certain as

that a vitiated secretion is the consequence of disease of a secreting organ. When such facts are considered, it seems surprising that, independently of all experimental research, it had not occurred to physicians, that in cases of chronic derangement of the assimilating functions, as in more acute affections, the fault might sometimes be in the brain or spinal marrow. But, being prepossessed with the opinion that they were organs of the sensitive functions alone, it was only in the more striking cases that the truth was forced on their attention.

Another circumstance has greatly contributed to the same effect. It appears from what has been said, that the centres of sympathy in the vital and sensitive systems are not identical; the functions of these systems, although wholly in the sensitive, and chiefly in the vital system, depending on organs which belong to the brain and spinal marrow, not depending on the same organs. Hence we have seen it is, that there is a centre of sympathy in a great degree independent of the feelings, many of the vital organs being parts of dull sensation; from which, we shall find, the most important practical errors have originated.

From the nature of the investigations in which I have been engaged, and the importance of the digestive organs in the animal economy, my attention was at an early period directed to them,* and particularly

* The thesis which it is necessary to print on taking a degree in the University of Edinburgh was, in my case, an account of experiments relating to that part of the process of digestion which takes place in the stomach; the results of which, although in opposition to the doctrines then prevalent, were admitted by the medical professors, and have never since been contradicted.

attracted by finding, in the course of my practice, that cases of indigestion occasionally presented themselves, which, although on the whole similar to the usual forms of the disease, ran a very different course, — at first not differing in any remarkable degree from the more usual cases, but at length assuming a formidable shape, without any distant organ appearing to be implicated, which is generally, in this country, the precursor of danger in ordinary cases of indigestion, and without any more formidable disease of the digestive organs themselves having made its appearance. Death seemed to arise from the failure of the digestive process alone ; there was no prominent symptom that was not referable to its organs ; and the patient, often much emaciated, appeared to die of inanition, in consequence of these organs, even where food could still be taken, being incapable of effecting the necessary changes on it.

It was in considering the nature of such cases, and comparing them with the effects I had witnessed from preventing a considerable part of the influence either of the brain or spinal marrow from reaching the digestive organs, that I was led to suspect that the fault might be in the central parts of the nervous system ; and, on examining the bodies of those who died in this way, I found the brain organically diseased, and particularly in the parts towards its base, from which the vital nerves proceed.

These cases had often, in their more early stages, been treated as cases of simple indigestion, and the friends been assured, that although, being more obstinate than usual, they would be tedious, there was no danger to be apprehended from them ; and I have seen some of the most eminent of our profession sur-

prised when I expressed an opposite opinion, in which, from the course of the disease, they themselves were at length obliged to join me.

I need not say that it is of essential consequence to be able to distinguish these cases from those of ordinary indigestion at an early period — the only period at which there is any hope of arresting their fatal course.

I shall, in the first place, point out the best diagnosis at which I have been able to arrive; for it will readily be perceived, by those acquainted with the principles of our profession, from what has been said, that there must be great difficulty in such a diagnosis. I shall then give an account of the appearances on dissection, referring to those in other cases of a similar nature, but of more general derangement, for the purpose of illustration; and, lastly, concisely point out the general principle of treatment, from which there is no hope, except in the earlier periods of the disease.

In the first place, of the diagnosis of the case before us. I have just had occasion to observe that the organs of assimilation must not only be exposed to disease from causes operating on these organs themselves, but on those organs also of the brain and spinal marrow, on the agent supplied by which their functions immediately depend; but as in both instances the disease consists merely of symptoms indicating derangement of the organs in question, — the digestive organs for example, — and a train of nervous symptoms, which more or less attend all such cases, the intelligent physician at once perceives the difficulty of distinguishing those cases which originate in

the brain; the patient either never complaining at all of the head, or only of such affections of it as we constantly see in common cases of indigestion. Yet it is evident that these cases must require very different plans of treatment, because, in the one, if we restore the digestive organs, the nervous symptoms, the mere consequence of their derangement, necessarily disappear; but in the other there are no means of restoring the digestive organs themselves, unless we can correct the disease of the brain or spinal marrow, or perhaps both, on which their derangement depends: for it follows from the experiments above referred to, — and we shall find the inferences from them amply confirmed by the phenomena of disease, — that affections of either may cause the symptoms we observe.

The difficulty is greatest when the cause is confined to the brain, because, as we have seen, the affections of the spinal marrow are generally attended with such local symptoms as necessarily call the attention to the seat of the disease. It is, therefore, to the diagnosis of those cases in which the cause is seated in the brain, that I shall here direct the attention.

The nature of the cases in which the original cause of the disease is confined to the brain, in consequence of the general nature of the functions of that organ, precludes the possibility of deriving the diagnosis from any particular train of symptoms: it must be collected from a review of the whole circumstances of the case; from the nature of the remote causes, both predisposing and occasional; the general course of the symptoms, and the effects of the means employed. I shall enumerate the circumstances which chiefly demand attention, and endea-

vour more particularly to point out the principles on which the diagnosis must be founded.

When the patient is not of a variable and hysterical habit, — when the occasional causes have been of a serious and permanent nature, and particularly such as directly act on the brain, and the nervous symptoms have not shown themselves for some time after the first application of such causes, — when there is not such derangement in the digestive or other organs chiefly affected as accounts for the severity of the nervous symptoms, — when the affections, both of mind and body, are less variable than is usual in what are called nervous complaints, and particularly when they are apt at all periods to be referred to the same parts of the body, — when there is constantly a more or less general tendency to derangement in the secreting system, — when the heart is more irritable and the lungs less free, the nervous symptoms not yielding so readily as usual, the depression of spirits more uniform, and the pulse tighter than we should expect to find it from the other symptoms, — when either the recurrence of feverishness or a sense of chillness and debility is more frequent than is usual in nervous complaints, — when the constitution seems more affected than usual by the continuance of the disease, the strength on the whole decaying, — and particularly when the countenance assumes a sallow colour and an habitually irritable and anxious expression, — when the usual means of cure are not attended with their usual effects, our stomachic medicines being in a great degree powerless, and alteratives producing but a transitory, if any, improvement in the abdominal secretions — when these, or several of these circumstances, are well marked in what are

called nervous complaints, I have been assured, by repeated observation, that they are not to be safely disregarded.

The diagnosis between the disease before us and the more common forms of indigestion is much assisted by observing the nature of the nervous symptoms in the two cases. There is in our frame, we have seen, what may in a great degree be regarded as two distinct nervous systems — the sensorial and vital. The sensorial functions may be disordered for a great length of time without endangering life, the vital functions, with the exception of respiration, having no dependence on them, and respiration, although often deranged, not being endangered till their derangement is extreme; but disorder of the vital system cannot go far without danger; and from our mistaken views of the functions of the nervous system it often happens, both where the disease has originated in its vital parts, and where it has spread from the sensitive to the vital parts, that danger is frequently unsuspected till, in consequence of the failure of the nervous influence, properly so called, disease of structure is established in some vital organ.

Thus it is that, in all cases of nervous debility, it is necessary to examine with care the nature of the functions chiefly affected. If these be the mental functions, and we find that there is little or no affection of vital organs but such as is evidently the effect of the derangement of the former, whatever be the sufferings of the patient (and these, from the chief derangement being in the organs of the sensitive system, are often greater than where there is more danger), we may be assured that life is little, if at all, threatened. If, on the contrary, the organs of life

chiefly suffer, and that independently of mental affections (especially if the course of the disease be more uniform than that of nervous affections usually is), however purely of a nervous nature the symptoms may be, and however little formidable either in appearance to others or to the feelings of the patient, danger is to be apprehended, and, if the pulse be decidedly and permanently tight, is not far distant. I have, in my Treatise on the Preservation of Health, and particularly the Prevention of Organic Diseases, entered at length into the nature, diagnosis, and treatment of such cases; the fatal termination of which I have often witnessed. Having been confounded with the less important nervous affections, their fatal tendency has frequently been so much overlooked, that when it at length showed itself, either by a decided affection of some vital organ or unequivocal symptoms of fatal inanition, it has sometimes found the physician, as well as the patient, unprepared.

By a due attention to the whole of the foregoing circumstances, we may generally distinguish the disease before it is far advanced; and I have reason to believe, from many cases which have come under my care, often succeed in arresting its progress by the means I am about to point out. In the mean time the nature of the disease will be further illustrated by turning the attention to the appearances on dissection after death.

This part of the subject will be best illustrated by giving the appearances on dissection in cases which, in their early stages, had been treated as common nervous and bilious complaints; in which I had

stated to the other medical attendants, that, notwithstanding there were no symptoms referred to the head, we should find the brain organically diseased.

The first case I shall mention is that of Mr. A., who was taken ill while pursuing his studies at Oxford. His case was regarded by the physicians of that city as one of common indigestion. His health not improving, he was brought to London, and placed under the care of two physicians well known to the profession here. After he had been in London a few weeks, I was called in, in consultation, and, guided by the foregoing circumstances, expressed my fears of a fatal termination, and stated my opinion, in consultation, that although the stomach and duodenum were the organs most prominently affected, I believed we should find the origin of the disease in the brain; and on dissection after death, which happened in a fortnight or three weeks after I saw the patient, and appeared to be the consequence of inanition, the following appearances presented themselves.

The body was examined by Mr. Walker, of St. George's Hospital. In this and the following dissection the examination was made about twenty-four hours after death, and the body in both cases was free from fetor. The following is his report respecting the case I at present refer to: —

" On opening the cavity of the cranium, the membranes and the brain were found tolerably healthy, perhaps rather softer than usual, particularly as regards the cerebellum and base of the brain, which, together with the medulla oblongata and cerebral nerves, appeared reduced to a pulpy state; so much so, that they would not bear the slightest handling.

"The viscera in the cavity of the chest presented no unusual appearances; the stomach larger than usual from distention, and presented that appearance which is called the 'hour-glass contraction' of that viscus in a more marked manner than is usually met with; the pylorus much more vascular than usual, and the duodenum much more dilated, vascular, and attenuated, than is natural. The whole of the small intestines were more distended with flatus, and much more gorged with blood, than in the healthy state, and of a very dark colour. The liver, spleen, kidneys, and pancreas, were healthy."

The following case was that of Miss C., which ran the same course as the preceding, but was of longer duration, having been protracted for more than two years; and here also the patient appeared to die of inanition. Some surprise was expressed that I should wish the head to be examined, as none of the symptoms had been referred to it. The examination was made by the late Mr. Earle, and the appearances in the brain corresponded, in a remarkable degree, with those just detailed. The symptoms in these cases, as well as the termination of the disease, had been similar, and we find the chief organic affection of the brain of the same kind, and seated in the same parts. The following is Mr. Earle's account of the appearances: —

"In the head, slight effusions beneath the arachnoid membrane; substance of the brain very soft, particularly the crura cerebri and upper part of the pons Varolii, which was quite pulpy. Blood-vessels in the substance of the brain large, and loaded with blood. In the chest, right lung greatly compressed by the narrowness of the inferior margin of the ribs,

from old adhesions between the pleura costalis and pulmonalis. Substance of the lungs firm and hepatised. Left lung more healthy than the right, but slightly hepatised at its upper part." This state of the lungs, it may be remarked, is peculiarly characteristic of a failure of nervous influence, as appears from those experiments in which the influence of the brain was prevented from reaching the lungs. The patient had been subject to cough and oppressed breathing; pulmonary symptoms, however, had never been a prominent part of the disease. "The heart," Mr. Earle proceeds, "was remarkably small. In the pericardium, about two ounces of water. In the abdomen, stomach and duodenum much displaced by the compression of the chest by the stays. Towards the pylorus, the stomach much thickened and indurated, the pylorus hard and contracted. The duodenum large and flaccid; the mucous surface very vascular, villous, and soft, readily breaking down on the slightest touch, and apparently approaching to a state of ulceration. Liver almost of a black colour, and gorged with venous blood: substance of the liver hardened. Spleen and kidneys small, but not unhealthy. Intestines generally of a dark colour, from venous congestion."

The circumstance of more general organic disease being found in this than in the preceding case, I shall presently have occasion to explain.

Cases like the foregoing, in which the patient wastes without an apparent cause capable of accounting for the degree of wasting, (for he sometimes takes a considerable portion of food,) have been often ascribed to mesenteric obstruction, which dissection has disproved, but without throwing light on their real

nature, because the necessity of examining the head has not occurred, none of the leading symptoms having been referred to it; and had it been examined, the appearances observed could not have been connected with the course of the disease, while the brain was regarded as the organ of the sensitive functions alone.

Such cases are not the consequence of the chyle being prevented from entering the blood, but of its not being formed, the processes by which it is formed having been suspended by the failure of nervous influence; for we have seen that the influence even of any considerable part either of the brain or spinal marrow being withdrawn, is sufficient to derange the process of digestion.

There is a case belonging to the same class (although no cases can differ more in their symptoms than it does from the preceding cases) to which I have already referred; the consideration of which is necessary to a clear understanding of the nature of that class of diseases. When the powers of the different organs are so well balanced that no part becomes the seat of a very prominent affection, and thus, as it were, draws to itself the effects of the failure of nervous influence acting on the principle of an issue, but much more powerfully with respect to other parts, and at length, by proving fatal, cutting short the disease before that of the brain has had time to run its course; — I say, where no part thus becomes the most prominent seat of the disease, the case necessarily assumes a very different form, and, if it be allowed to proceed, terminates by loss of power in the brain itself — a case of very rare occurrence;

for the usual termination of such cases, we shall find, is some particular vital organ being disorganised in consequence of the general failure of nervous influence, before the state of the brain can become such as itself to prove fatal.

We may infer from what has been said, that we should find, on examination after death in such cases, a general tendency to disease of the vital organs, the disease having run on till the want of nervous influence was felt throughout the system ; and more or less general derangement of structure had consequently taken place, but none to such a degree as itself to prove fatal. It will best illustrate these observations to lay before the reader an account of a case of this kind, which, in a less degree than the one I have here selected, is by no means very uncommon, with the appearances on dissection after death.

Mrs. W., a lady between forty and fifty, had from time to time been under my care for some years. She had, more or less, laboured under indigestion, with occasional symptoms of derangement, sometimes referred to one part, sometimes to another, which were from time to time relieved ; and on the whole, although debilitated and what is called nervous, she was for the most part capable of the ordinary duties of life. By degrees the symptoms referred to the head became a more prominent part of the disease. She had been absent from home for some months, during which the affection of the head had greatly increased, and returned in such a state that she soon became apoplectic, and only survived her return about a fortnight.

The body was examined by Mr. Jefferson of Islington, and the following is his account of the appearances observed : —

" The skull was remarkably thin; in most places not thicker than a shilling. The coverings of the brain very turgid with blood, (you would rarely see them more so in a complete case of apoplexy,) with a deposition of serum and coagulable lymph between the arachnoid and pia mater. The substance of the brain itself was very firm, and much more vascular than natural; there was rather more water in the ventricles than usual, but no great quantity.

" The lungs were very unhealthy on both sides, being studded with small tubercles, many in a state of suppuration, and others approaching to it. In the heart there was nothing remarkable; perhaps rather paler than natural.

" The liver remarkably firm in texture, and rather paler than natural, but no very morbid appearance in it; the gall-bladder rather larger than natural, and distended with thick viscid bile, and containing fourteen gall-stones, bigger considerably than as many large peas. There did not appear to be any of them in any of the ducts. The stomach was rather smaller than natural, the coats of which were much thickened; the internal or villous, so firm that it could not be easily torn. The pyloric extremity showed more vascularity, as if from the effect of recent inflammatory action; and it adhered for a considerable extent to the diaphragm and left lobe of the liver. There was nothing particular throughout the remainder of the alimentary canal. The spleen larger than natural; the bladder much distended, but no disease; the uterus remarkably firm, so as to give a cartilaginous feel upon cutting into it; the os uteri very vascular, with a small polypus excrescence from the neck."

We here see a striking instance of the effects of

long-continued defective nervous influence. The lungs were very unhealthy, and studded with tubercles, although the disease had never appeared in them in an active state. The secreting power of the liver had been greatly deranged, and this organ was found diseased in structure. The same was true of the stomach, spleen, and uterus. The brain itself, also, was organically diseased, and the patient, none of the secondary affections proving sufficient to destroy life, died in consequence of such morbid distention of its vessels as caused a fatal compression.

The difference in the course of the disease in this and the preceding cases may have been influenced by the affection of the brain being of a different nature.

We see the same tendency to general organic disease in the second of the above mentioned cases, which, like Mrs. W.'s, had been of long standing, but in which the disease of the brain was cut short by a total failure of power in the digestive organs. In the first of the three preceding cases, the organic disease was chiefly confined to the duodenum, its state being such as to prove fatal before the failure of nervous influence had had time to produce much effect in other organs less disposed to disease; this case having only lasted a few months, and the tendency to disease in the digestive organs, arising from peculiarity of constitution or other causes, tending to protect other parts.

I NEED hardly say, that it appears from the facts detailed in the preceding part of this volume, that when the cause originates in the brain, the tendency to derangement of function must be general, including the functions both of the sensitive and vital system;

and such we find is the case. My limits do not permit my entering on the detail of treatment in such cases, for which I must refer to my Treatise on the Preservation of Health, and particularly the Prevention of Organic Disease. The great object in the prevention of functional, degenerating into organic disease, is of course as early as possible to restore and maintain the healthy functions of the parts affected. In the case before us, therefore, the treatment, which can only be successful at a very early period, is to correct the deranged and maintain the healthy function of whatever organ, whether of the sensitive or vital system, in which derangement shows itself; and consequently the patient's only chance of recovery depends on the nature of his disease being ascertained at an early period: for it is only before any degree of disorganisation of the brain supervenes, that a treatment founded on this principle can be successful, and no other can avail.

Such are the forms assumed by a debilitated state of the vital organs of the brain, when the offending cause immediately influences the brain itself. This, which of all cases belonging to the present section is the most obscure in its early stages, and in all its stages the most difficult of treatment, is fortunately the most rare.

It will appear from a very cursory review of the results of the preceding part of this volume, that it is only in certain rare cases, where no particular vital organ is more inclined than the rest to organic disease, or where the disease is a partial affection of the vital organs of the brain, and originates in some parts of that organ itself, that change of structure can take

place in it; because it was found, on the one hand, that any considerable diminution of its general power is sufficient so to derange the structure of some other vital organ, as in this way for the most part to prove fatal before any general affection of the brain could be such, as to terminate in change of structure in the brain itself; and on the other, that when the disease originates elsewhere, its operation on the brain must always be a general, not a partial operation, because we know from direct experiment that each of all other vital organs receives nerves from all parts, and is capable of influencing and being influenced by all parts of it.

2. *On a debilitated State of the Brain and Spinal Marrow, in which the offending Cause makes its Impression on the Organs of the Sensitive System only.*

With respect to that form of the disease which originates in the central organs of the sensitive, from which it spreads to those of the vital system, its diagnostic symptoms and general course are the same as in the forms of disease we are next to consider; except that they are preceded by suffering of the sensitive system, and attended by greater, and, compared with the other symptoms, more prominent derangement of that system, than in them; for such is the sympathy which exists between the central organs of the two systems, that in all cases they each partake of the affections of the other; of which the vicinity of the organs on which their powers immediately depend, alone, we have seen, is a sufficient cause; but independently of this cause, each more or less partakes of the functions of the other; for even in man the

spinal marrow partakes of some of the functions of the sensorial organs, although very little compared with what we find to be the case in some of the animals called less perfect.

In the case before us, we have reason to believe from all that has just been said, that when the functional derangement of the central organs of the sensitive system — that, for example, caused by a settled grief — debilitates by sympathy those of the vital system, it will, long before it can produce organic disease in the latter, by that sympathy so derange the supply of nervous influence to the vital organs throughout the system, as to cause a fatal disorganisation in some of them. It is possible, although, from the vicinity of the central organs of the two systems, it probably rarely occurs, that the derangement of those of the sensitive system may terminate in *their* disorganisation, before the central organs of the vital system have so far partaken of the derangement, as to produce a fatal disease of structure in a distant part; the usual termination where such a case proves fatal.

As the principles which operate, both in the production and treatment of such cases, are the same as in those of the diseases which form the subject of the next division; and as the offending cause operating in the sensitive system is always an evident one, without the removal of which no plan of treatment can be successful; and with that, in all curable stages of the disease, little else is required to secure recovery; there is little to detain us in the present division of the subject. I shall have occasion in that which follows, which is on every account the most important, again to refer to the diseases which belong to the present division.

3. *On a debilitated State of the Brain and Spinal Marrow, when the offending Cause makes its Impression on some other vital Organ.*

The diseases arranged under the present division are important on every account which can render a disease worthy of careful consideration. We shall find them among the most frequent and complicated of all diseases; in their early stages, although almost uniformly curable, attracting little attention; in their advanced stages, both difficult of treatment and of doubtful prognosis; and in their last stages, with few exceptions, in the present state of our profession, necessarily fatal.

The circumstances which chiefly characterise the diseases I am about to consider, are their little apparent consequence in the commencement, and the little apparent connection which their first stage has with the stages which follow, in a great degree to be ascribed to the physiological errors which prevail in our profession. From these circumstances the danger in a great degree arises; and the obscurity is not a little increased by the disease, in many instances where the nervous system is naturally strong, and encounters no other cause combining with the disease to impair its powers, never advancing beyond its first stage; which tends still farther to confirm the opinion of the innocence of that stage by tending to prevent our associating it with the more formidable stages.

I shall, in the first place, consider the nature and most frequent seat of this first stage, and then, from the results stated in the first part of this volume, point out what must often be the consequences of its continuance; which, we shall find, is precisely what

happens in those cases where, either from the too great severity of the offending causes, or the too little resistance in the organs concerned, this first stage runs the course which, under either of those circumstances, is, I believe, in the present state of our profession, unavoidable, if the means I am about to point out be not employed to prevent it.

The diseases I am about to consider consist of three distinct stages: The first, merely of the affection of the parts on which the causes make their impression. The second, a state of general nervous irritation induced by the continued causes of irritation existing in those parts; for the nervous system, being a whole, if irritated in one part, is more or less irritated in all; and the symptoms of this stage of the disease are infinitely varied, according to the tendencies of different constitutions, times of life, and the circumstances in which the patient is placed.

As soon as the fret of nerves caused by the original disease becomes permanent, wherever it may have originated, the immediate cause of the general sufferings is in the central organs of the vital system, on which all causes of irritation existing in that system necessarily make their impression, the affection of the part in which the original cause of the disease exists, still being the seat of the most important derangement; although the long-continued irritations of the vital system have, as must at length happen, wherever they exceed the power of resistance in the central organs of that system, induced in them more or less functional derangement.

Under these circumstances, except in the most vigorous constitutions, they cannot long continue capable of supplying in the due degree the nervous

influence, on which the assimilating, secreting, and excreting functions throughout the system depend. There is, therefore, a general tendency to failure in these functions; and if there be any of the vital organs from other causes more inclined to disease than the rest, this organ chiefly suffers, and, according to a well-known law of our frame, acts as an issue in relieving all others, and becomes the chief seat of the disease induced by the functional derangement of the vital organs of the brain and spinal marrow; and will even relieve the diseased state of that organ on which the causes of the disease made their impression, and consequently from which the whole disease has originated; a circumstance which has tended greatly to obscure the nature of these cases.

Such is the third and fatal stage of the disease, and the reader will easily perceive why it is necessarily fatal, if the train of events which have led to it be overlooked. The original cause of irritation, although generally alleviated by the supervention of the new disease, still continues, still farther increasing the functional disease of the central organs; and the only chance of safety is ascertaining the original affection, and removing it; which, for reasons which will appear, may often be done even in this advanced stage, and thus life saved; provided the last supervening disease has not produced actual change of structure: the tendency to which, as might be foreseen, will depend on the degree in which the powers of the vital organs of the brain and spinal marrow have suffered.

We thus relieve the central organs from the cause which has impaired their powers, and afford the only remaining chance of their regaining, by the proper treatment, their healthy functions; and thus of re-

lieving the organ last affected, in the affection of which the immediate danger always lies; and which is more pressing than the same affection arising from other causes, in proportion as the central organs, on which the structure as well as the functions of all our organs depend, have been debilitated by the previous course of the disease.

The seat of the affection with which the diseases we are considering commence, rather than the cause which produces them, determines their nature; because they may arise from any causes which tend to derange the functions of the parts concerned, and for a sufficient length of time maintain the derangement; and to such causes those parts of course are most exposed which, on the one hand, from the structure of our frame, are most exposed to causes of irritation, and on the other, in which the sympathies of our frame are most extensive. There are no organs to which these observations so extensively apply as to the digestive organs, the stomach, liver, and first bowel, called the duodenum, which, strictly speaking, is rather to be regarded as a second stomach than as a bowel, for it is in this organ the digestion of our food is completed, we have seen, and brought into a proper state to be mixed with the blood, and converted into the various organs of our bodies.

Similar observations also apply to the remaining part of the alimentary canal, but, for several reasons, in a far less degree, for the causes of irritation operating on them alone are not frequently the source of the diseases which belong to the present division of the subject, because their causes of irritation are of a temporary nature, and their most powerful sympathy is with the central organs of the sensitive, not

those of the vital system, which, it appears, from what is said in the introduction to the present division of this treatise, are not identical. It now and then happens, however, that such is the result. I shall here give a concise account of such a case, on account of its rarity, and because it strikingly illustrates several important positions respecting the nature of this class of diseases.

The case I refer to was that of a lady who had for many years been exposed to the frequent recurrence of severe irritation of the bowels; yet this state of the bowels depended little on bilious derangement, as it is usually found to do. She did not labour under the diagnostic symptoms which always attend the disease I term distended liver, when of long standing, the diagnostic symptoms of which I shall soon have occasion more particularly to point out; and occasional mercurial doses never gave even the temporary relief they usually do in such cases, but only added to the irritable state of the bowels.

Her attacks gradually became more frequent, till at length her strength was permanently impaired. In a short time after this, she became the subject of an obstinate cough, which had never been the case at any former period of her life, although she was now between fifty and sixty years of age.

As she was past the time of life when a disposition to pulmonary consumption usually appears, and her family on neither side had been subject to this disease, the cough excited little alarm; but this, like her other symptoms, proved obstinate, the effect of the gradually increasing debility of the sources of the nervous power properly so called, and in a very short time after it had attracted serious attention, symptoms

indicating diseased structure of the lungs appeared. Her debility was such that she became subject to sudden fainting fits, and general anasarca supervened. She was now confined to bed, and died of one of the most rapid cases of pulmonary consumption I have witnessed.

The central organs of the vital system had been previously debilitated by the constantly recurring irritation of the alimentary canal, without any other morbid affection, although, as I have just observed, the more evident sympathies of this canal are, from its great sensibility, rather with the central organs of the sensitive than those of the vital system. The relations were surprised that a person at her time of life, who had never shown the least disposition to such a disease, should have been carried off by a more rapid attack of it than they had ever known in any other case.

Here the central organs of the vital system were injured both by the direct effect of the irritation, and sympathetically by the effect produced on the central organs of the sensitive system by an affection of so extensive and highly sensible an organ, and of such continued recurrence. By the previous disease, the system was in every way prepared for the result when the affection of the lungs supervened: the central organs of both systems had been strained, hence its rapid progress. Can any one, aware of the laws which regulate the vital functions, as appears from what is said of those functions in the first part of this volume, now generally admitted to be correct, doubt that if in this case the irritable state of bowels, which was supposed to be attended with no risk to life, could have been prevented, the patient's life would have been saved? Here we see causes gradually and

imperceptibly undermining the functions of the brain and spinal marrow, till they were no longer capable of supplying the due degree of nervous influence, and that organ, which at any period of life is apt to suffer from such a defect, rapidly yielded to it; although produced by a cause which was thought, both by the patient and those she consulted, to be of too little consequence to be seriously attended to.

In this lady's constitution there was so little predisposition to serious disease, except in the alimentary canal, that the lungs became the seat of the last supervening and fatal part of the disease, merely because they are the organs, from the nature of our constitution, most liable to change of structure.

Although the state of the alimentary canal, that is, the canal from the end of the duodenum downwards, is rarely the only source from which such diseases spring, in a great proportion of cases it powerfully contributes to their production; both by the causes of irritation existing in itself, and by its immediate influence on the organ, which we shall find the most fruitful of all the sources of such diseases in this country.

The intimate connection between the alimentary canal and the liver, the fluid secreted by which is at once the means of completing the digestion of our food *, and regulating the action of the intestines, greatly increases the influence of that canal through-

* See Sir Benjamin Brodie's paper entitled "Observations on the effects produced by the bile in the process of digestion, in a letter to the editor, by B. C. Brodie, Esq., F.R.S., professor of anatomy and surgery to the Royal College of Surgeons," in the 14th volume of the Quarterly Journal of Science, Literature, and the Arts.

out all parts of the system ; and in particular, from the peculiar sympathies of the liver with the central organs of the vital system : as, in its turn, the liver, through the alimentary canal, obtains an influence on those of the sensitive system ; which, from its being so ill supplied with nerves of sensation, it only in a slight degree itself possesses.

The affection of the organ in which the diseased state of the brain and spinal marrow we are considering originates, must have two conditions. It must belong to an organ little disposed to change of structure, and its immediate effects must not be such as directly threaten life. Without the former condition it could not be of so chronic a nature as to produce debility of the central organs, which, when it arises from such a cause, is always the effect of long-continued or very frequently-repeated irritation. Without the latter it could not be so lightly considered as it usually is, either by the patient or medical attendant, not only at an early period, but even in its more advanced stages, to be often almost wholly disregarded.

The first points of consequence which here present themselves, are to ascertain the organs on which, in such cases, the offending causes are most apt to make their impression ; and the nature of the diseased states produced in them. If the latter can be detected and removed, all that follows is of course prevented. If the last stage has been allowed to appear, the safety of the patient, as I have just had occasion to observe, depends on distinguishing it from a case of original disease of the part now most prominently affected, and tracing the disease to its origin ; because, unless the cause which has produced, and is *à fortiori* capable

of supporting it, can be detected and removed, our means must either be altogether ineffectual, or afford imperfect and but temporary relief.

Of all our organs, the liver is that which most influences and is most influenced by the state of the alimentary canal, and in a large proportion of diseases it is the source of some of its most powerful causes of irritation. I have, both in the former editions of my Treatise on Indigestion, and my Gulstonian Lectures, entered at length into the proofs of the extensive influence of the liver, although an organ of little sensibility on the sympathies of our frame; by which, more than any other cause, the consequences of its morbid states are regulated; a circumstance in a considerable degree depending on its intimate connection with that canal, but in a far greater degree on the immediate connection which exists between it and the vital organs of the brain — a connection far more powerful than exists between any other part and those organs. Even affections of the mind are capable, through the central organs of the sensitive and vital systems, of immediately deranging its function. Its chronic diseases cause melancholy, as the term itself expresses, and its acute diseases delirium, while the mind remains steady to the last in similar affections of all the other thoracic and abdominal viscera; for its influence is great on the central organs of the sensitive system, although it is so ill supplied with nerves of sensation, arising from the powerful sympathy which exists between the central organs of the two systems, and the direct influence of its affections on the alimentary canal, one of the most sensitive of all our internal organs.

Thus it becomes the most fruitful source of the class of diseases we are considering. Owing to its little sensibility, its slighter and more habitual affections, notwithstanding its great influence in the vital sympathies, are often overlooked, while, from its function regulating that of the alimentary canal, its influence is spread over the most extensive and sensitive surface; and, when to these circumstances its direct and powerful influence on the central organs of the vital system is added, we cannot be surprised at its effects, both in causing and regulating the course of disease.

It is a striking fact, and powerfully illustrates what I am now saying, that in sultry climates, particularly the East Indies, where our sympathies are most, and for the security of health too active, almost all diseases of long standing, however they commence, terminate in disease of the liver; and even in temperate climates its general influence on all important diseases may be observed. We never see any serious disease in which its functions are not more or less deranged; but here its affections are less observed, and, if I may so speak, less monopolise disease, because they are much less than in sultry climates disposed to run into deranged structure; and disease of structure is more powerful than that of function, in relieving all concurring diseases.

If these facts be such as here stated, and by the well-informed and experienced physician they are too notorious to be questioned, — I say, if such be the facts, and we had understood the nature of the diseases which form our present subject, we might have foretold that the liver must perform an important part in their production; and how amply such a prediction would have been confirmed by actual practice,

did my limits admit of it, I could prove by reference to many diseases of the class we are considering.

Another circumstance which renders the states of the liver of the first importance in these kingdoms is, that in them derangement of its function is of all diseases the most hereditary. We often find whole families at the same time labouring under it and its consequences. Thus it proves the most fruitful source of the diseases we are about to consider.

Even the slighter affections of the liver, we shall find, although themselves unattended with danger, often are, from the properties peculiar to it, of the first importance, and have not met with the attention they deserve. Because there is no vital organ, even a capillary vessel however minute, we have seen, that is not directly influenced by, and which cannot itself directly more or less influence, every part of the brain and spinal marrow, and the functions of no other organ so much influence, and are so much influenced by the state of the brain, as those of the liver. I shall here enter particularly into the nature and diagnostic symptoms of the affections here referred to, and afterwards state the facts which prove their immediate connection with many of the most fatal diseases to which we are subject, and the fatality of which, we shall find, depends on the physiological errors which have been pointed out in the first part of this volume.

As we have not been aware, as appears from what is there said, that the organs of the leading power in the vital system reside in the brain and spinal marrow, and that any cause disturbing the functions of any of these organs, supposed to be those of the sensitive

system alone, may directly influence any other of the vital organs, and that the state of any of the latter is capable of directly influencing the vital organs of the brain and spinal marrow — I say, not being aware of any of these circumstances, we could not be prepared for the observations I am about to make; but, having before us the facts on which these positions are founded, if we find at the same time that the daily phenomena of disease prove that, on the one hand, any cause which permanently debilitates the brain or spinal marrow, and still more both of these organs, in the same proportion tends to impair all the vital functions, and at length may derange the structure of any of their organs; and, on the other, that a permanent disease of any vital organ, however inconsiderable, directly tends to debilitate the vital organs of both the brain and spinal marrow;— I say, if such be both the physiological and practical facts, it is doubly proved that a fruitful source of disease has been more or less obscured by our physiological errors. Such are the general principles which cause the morbid affections of the brain and spinal marrow jointly to be so frequent and important; in their origin often so obscure, and often so fatal in their termination.

We are thus led to inquire into the causes which tend to debilitate the organs on which the maintenance of all parts of our frame depends, to endeavour to trace their first beginnings, and to inquire into the means of arresting a change which necessarily tends to a fatal issue.

I HAVE just had occasion to refer to the facts which prove that, of all our organs, the one which, both in

consequence of its own sympathies and those of the organs with which it is connected, most influences the vital organs of the brain and spinal marrow, is the liver. Certain affections of this organ may be regarded as the endemic of these kingdoms, there arising, as I have already had occasion to observe, partly from their hereditary nature, and partly, we have reason to believe, from the changeable nature of our climate. So frequent in this country are the less severe functional affections of the liver, that if any five persons we meet be examined, at least in one, perhaps in two of the five, it will be found more or less functionally deranged; that is, out of any five, one or two will be found to be more or less what is called bilious; a term which the little attention which has been paid to the slighter affections of the liver has caused to be used in a very indefinite sense, so much so, that, in attempting a more correct view of the beginnings of the diseases we are about to consider, it will be necessary to dismiss this term, which, we shall find, includes affections very different in their nature, and use less equivocal language. I am here, then, to consider those slighter disorders of the liver, which, however in themselves free from risk, may, like any other chronic affection of a vital organ of long continuance, in process of time, sooner or later, according to the age and constitution of the patient, and his family tendencies, through the vital organs of the brain and spinal marrow, lay the foundation of any one of a large proportion of the most fatal diseases to which we are subject.

This gives to them an importance which does not at first viw belong to them, for the affections of the liver of which I speak, never, according to my expe-

rience, in temperate climates, independently of other concurring causes, injures its structure. I have never, in this country, on the one hand, seen organic disease of the liver, produced by the disease, however ill defined, known by the name of bilious complaints, where such complaints depended on an original affection of the liver, namely, the state of the liver I am about to describe, even where it had lasted for the greater part of life; and, on the other, in all the numerous cases of disorganised liver in which I have been consulted, during an extensive practice of between thirty and forty years, they have always been found to arise from other causes. I am well persuaded that what are accurately called bilious complaints never in this way and in this country lead to danger. It is in the way above pointed out that they ever produce a fatal result. But for every case of disorganised liver, I believe I speak much within bounds when I say, we see a hundred of permanent functional derangement and consequent distention of this organ.

I am now to present to the reader a careful review of the nature and tendencies of this disease, and the treatment I have found most successful in removing it, and finally correcting its tendency to return. I shall, in the first place, point out its diagnostic symptoms, by which we shall, on the one hand, clearly perceive what constitutes the disease, and on the other, be able to ascertain with accuracy its state in all its periods, without which it is impossible to conduct the only treatment which has proved successful in a disease which the occurrences of every day, we shall find, without the necessary cautions, are liable both to confirm and to aggravate. By these

means we shall be enabled accurately to define its nature, that is, to trace the defect on which it immediately depends; and thus distinguish it from other diseases, which it so nearly resembles, that in the present state of our profession we have no diagnostic applicable to all cases; some of a very different nature, and consequently requiring very different, and even in some respects opposite, means of treatment, being known under the vague denomination of bilious complaints.

We shall also thus be enabled to ascertain with accuracy the state of the disease at all periods of treatment; a condition we shall find essential to its successful treatment, and even for the purpose of ascertaining when the finally successful cure is effected.

By such means we shall be enabled to judge with accuracy of the degree in which its cause exists in each particular case, and, from time to time, of the effects produced on it by the plan of treatment adopted; points greatly required in a disease which often produces such disturbances in the nervous system, *that both the sufferings and the danger are generally proportioned more to the excitability of this system, than to the degree in which the cause of the disease exists;* a circumstance which we shall find essentially influences both the prognosis and treatment. Having pointed out the diagnostic symptoms and their more immediate attendants, I shall then consider the consequences most to be apprehended from the continuance of the state they indicate, and the symptoms which point out the approach of such consequences during the curable periods of the various forms of this insidious, and, in these kingdoms, frequent disease.

Of the Nature and Diagnostic Symptoms of permanently distended Liver.

The liver, when healthy both in function and structure, lies entirely under the ribs. When the structure is disordered, it is generally, and sometimes greatly, enlarged, and therefore descends below the ribs; less frequently it is contracted in size. To such cases the present treatise does not extend. They are well understood, and from the nature of the symptoms cannot at any period be disregarded.

It is the functional derangement of the liver alone to which I wish to call the reader's particular attention, and that after it has become habitual. The liver is then found uniformly so distended, from the accumulation of bile in its ducts, as to descend below the ribs, and it is easy to ascertain the extent to which it does so, because, although there is no hardened edge to be felt, as in the case of enlarged and indurated liver, there is a greater degree of fulness than in the corresponding parts of the left side as far as the liver descends; and the patient feels the breathing more affected by the pressure on the full parts, than by similar pressure on the corresponding parts of the left side; while, as I have ascertained, both alone and with other physicians, in a perfectly healthy subject no difference can be detected, either by the feelings of the patient or the hand of the physician, between the corresponding parts of the two sides. The pressure being made through the integuments and muscles, the difference is not sensible to the hand of the physician, when it is only the ex-

treme edge of the liver which comes below the ribs; but, however little this is the case, the pressure will always cause the patient to feel the breath more affected than on the other side, because it will still more or less press the liver upwards against the lungs; whereas, when the liver is wholly under the ribs, its natural position, no effect of this kind can take place. The standing position is the most favourable for the examination, because it is in this position that the distended liver approaches nearest to the parieties of the abdomen; and as there is no hardened edge, the degree and extent of which we wish to ascertain, when its structure is disordered, any action of the muscles which in this position takes place is no impediment towards ascertaining with accuracy the degree to which the liver is distended by the effect produced by the pressure on the lungs, and how far at any period of the treatment it has regained its healthy size, and consequently retired to the position which a healthy liver always occupies. If there be any difficulty in determining the degree of distention, it will be much lessened by desiring the patient to speak while we compare the effects of the pressure on the two sides.

But the liver is not the only organ that is morbidly distended when its function is impaired.

As the morbid distention of the liver I here speak of chiefly arises from the bile to a greater or less degree accumulating in and distending its ducts, this fluid cannot under such circumstances, with regularity, and in either the proper quantity or quality, (for it always acquires morbid properties when too long detained in the liver,) be regularly supplied to the duodenum, that is, the first bowel, or rather the second stomach;

for the digestion*, we have seen, is completed by the food in this bowel being mixed with the bile and other juices, by which and the peculiar action of this bowel it is converted into what in medical language is called the chyle, in which state, as appears from what is said in the first part of this volume, it is prepared to enter the blood and be converted into the various organs of our bodies by the process there described. The chyle, therefore, is always imperfect if a due supply of healthy bile is prevented, and the contents of this bowel fail in the properties required for maintaining its healthy action.

Thus it happens, that when there is a morbid accumulation of bile in the liver, there is more or less a morbid accumulation of the contents of the first bowel into which the stomach discharges the food, which, in the state in which it leaves the stomach, we have seen, we call chyme; and in proportion as the liver becomes distended with the bile, which its ducts have not power fully to discharge, the first bowel, in consequence of the bile, one of the stimuli which maintain its due action, having, from detention in the liver, acquired morbid properties, and consequently failing duly to excite it, allows its contents more or less to accumulate, producing a morbid distention in the region of this bowel also. Its contents are always more or less transmitted, but this is effected less perfectly than it ought to be. I have never seen one instance of distended liver, if it has lasted a considerable time, unaccompanied by a distended duodenum, which is easily ascertained by the

* See the experiments of Sir Benjamin Brodie on this subject—Brand's Journal (Royal Institution).

increased fulness felt by the hand on pressure on the region of this bowel, and the pressure having the same effect on the breath as that on the region of the distended liver, but less in proportion as the distended bowel is less firm and at a greater distance from the lungs; and such is the enlargement occasioned by the distended state of these two organs, that when their due functions are restored, if the complaint has been of long standing, women, even when little or no thinner, generally find it necessary to lessen the width of their stays from three to five inches.

Now these two states of distention are the diagnostic symptoms of the disease I treat of; and however much other cases may resemble it, where there is no distention of these organs, I have uniformly found that this particular state of the liver, namely, a permanently distended state, has had no share in producing the disease; and that the treatment adapted to bilious complaints, as here defined, is of no service, and consequently injurious, except as far as may be necessary to relieve bilious symptoms occasionally attending them. To prevent all ambiguity, I have in my later publications called the disease before us distended liver. Such, then, are the diagnostic symptoms, according to the present treatise, of the common bilious complaint, properly so called, of these kingdoms, when confirmed, which is so common that it deserves the name of their endemic; and the rate at which the cure of this disease advances, or recedes, can at all periods be determined by the degree of distention of the liver and first bowel; or rather, as appears from what has been said above, the second stomach. It is not till the food leaves this bowel that its digestion is completed, and it is duly prepared to enter the blood by means of the

absorbent vessels of the remaining bowels; which convey it to be acted upon by the chemical power of the nervous influence, conveyed to the contents of the capillary vessels by the nerves, by which the chyle thus conveyed is converted into the various organs of our bodies and their state of health maintained, as explained in the first part of this volume.

We are now to consider the more remote and less uniform consequences of a permanently distended, although, as far as the structure is concerned, a healthy state of the liver In some, even the permanently distended state of the liver, and consequently of the first bowel, when not considerable, and in those of strong nerves, continues to be of trifling importance; so much so, that the subject of them considers his general health good. And such is on the whole the case; the chief inconveniences being a tendency to flatulence and languid bowels, sometimes occasional heart-burn, symptoms which in such cases are easily relieved, and but little, if at all, affect the general health; and in this state I have known some, although such cases are rare, remain for the greater part of life; the symptoms which belong even to a permanently distended state of the liver and duodenum in such habits being much less important than, considering the nature of the functions of these organs, we should be inclined to suppose. It is, however, necessary to regard these as exceptions to the general case, in which the permanent distention of these organs, however slight, brings on, more or less, after the lapse of a certain time, a permanent fret of nerves, with the consequences above described. The exceptions arise from an extraordinary power of

the brain and spinal marrow in consequence of which the nervous fret never becomes permanent. It is necessary carefully to distinguish this disease from the temporary distention of the liver not uncommon in fits of indigestion, for even in such cases it will now and then for a few days attend disordered stomach.

The difference consists in there being no permanent distention established, either in the liver or duodenum, in the latter case; and both liver and duodenum, if the latter also has partaken of it, soon recover from the temporary debility caused by the oppressed stomach; and thus two or three moderate doses of calomel taken at night, and carried off early next morning by any ordinary aperient, puts an end to the attack; but if such attacks be frequently repeated, or causes occur to prolong them for a considerable length of time, a permanent debility and consequent distention of the liver is established, and its necessary consequence, a permanent distention of the duodenum. It then depends on the state of the nervous system, whether this affection of these organs, although now established, prove still one of comparatively little importance, or one of the most formidable of all the chronic diseases to which we are subject; for as in our profession the distinction between this and the temporary affection is not at present made, if the patient is saved from the usual consequences of the former, it must be by the strength of his constitution alone. At present the practitioner is not even aware of the existence of the state of parts which constitutes a confirmed debility of the liver.

In some constitutions in which the nervous system is particularly powerful, the above state of parts, we

have just seen, may continue for the greater part of life without occasioning such an irritation of nerve as causes serious and permanent distress; but the usual consequence is, that in the course of a few years, particularly where other causes of nervous irritation have occurred, the symptoms indicating a general fret of nerves become permanent. Under such circumstances the disease always, and, as appears from what is said in the first part of this volume, necessarily preys on the brain and spinal marrow, the only organs which supply the nervous influence, on which all the more complicated vital functions depend. Thus, by degrees, their vital organs being debilitated, the supply of this influence gradually fails, and if there be any other vital organ rendered weaker than the rest by previous disease or any other cause*, this organ yields to the generally diseased state of the system, and then, the central organs having been debilitated, the danger is extreme; and its treatment, to give any chance of recovery, depends on the removal of the original cause, the distended state of the liver and duodenum, of which if the practitioner is not aware, the case is necessarily fatal.

One of the most frequent of the occasional attendants of a permanently distended liver is tenderness on pressure in the region of the pylorus, where the morbid fulness is chiefly perceived; a symptom, we shall find, of great importance in the treatment, rendering it both more complicated and tedious, and

* The liver itself, we have seen, never, in this country, under such circumstances, becomes the seat of diseased structure. But, were no particular vital organ so debilitated as to fix the disease in it, the whole of the vital organs would yield to the offending cause sufficiently to render the result equally fatal.

arising from a chronic inflammatory state of the pylorus, more or less extending to parts in its neighbourhood. I have often found, on dissection, the pylorus, in those who had long laboured under permanent indigestion, as red as if it had been affected with acute inflammation. It is evident that while other parts of the stomach are exposed to the undigested contents which happen to lie next them, the pylorus is exposed to the whole. All must pass by this orifice.

I have never seen an instance, however, in which this tenderness was attended with pain or any other symptom of acute inflammation. The patient is never sensible of its presence, till pointed out by the effect of pressure on the part. The pains occasionally attending distended liver appear to be all of a spasmodic or rheumatic nature, and generally referred to the stomach, or other muscular parts.

The inflammatory state of the pylorus spreads to the left edge of the liver, and in some cases to a considerable distance along this organ, or, on the other hand, along the stomach, as may be ascertained by pressure on those parts. More rarely there is a sense of tenderness also in the region of the distended duodenum; but this, unless very considerable, often requires but little attention, as it very frequently disappears when the tenderness of the pylorus is relieved.

Of such consequence is this tenderness in the treatment, that I cannot recollect a single instance in which the liver has ever retired into its proper place till the tenderness was subdued; the removal of which, therefore, we shall find, forms an important part of the treatment, its presence always more or

less, and often greatly, protracting the cure. Being of an inflammatory nature, it tends to bind up the surfaces, whereas the object of the treatment is to relax them, and cause a free flow of the secretions. The tenderness accompanies more than two-thirds of the cases of distended liver, and appears to depend on the inflammatory habit of the patient, those who are most disposed to it being also most disposed to feverish heat, more or less tendency to which accompanies a large proportion of cases, being induced by the various irritations which attend the more severe cases. Such may be regarded as the first stage of permanently distended liver, which in those of strong nerves, we have seen, will sometimes continue for the greater part of life without assuming any more serious form.

When it makes the next step, the patient's state is essentially altered.

On the first Stage of the Debility of the Brain and Spinal Marrow, being the second Stage of distended Liver.

Although in those of strong nerves a distended state of the liver, we have just seen, in a certain degree may remain for an unlimited time, particularly if unattended by pain on pressure, without producing any serious consequences; in many, and certainly in the majority of cases, this and the distended state of the duodenum, which, we have seen, always, and indeed necessarily, accompanies it, gradually, unless the distention is very trifling, begin to fret the nerves of these organs. As soon as this takes place, the nature

of the disease is altogether changed. It is now no longer a mere affection of the digestive organs, but a disease of the whole system, combined with the disease of those organs from which it originated, and having its centre in the brain and spinal marrow.

The vital system is a whole, which if fretted in any one part is apt to become fretted in all.

The disease is thus rendered one of the whole system, and the symptoms which then arise are of infinite variety, varying with the endless variety of constitutions, and agreeing only in this, that they produce more or less in different cases a disturbed and restless state of the system; for although the disease originates in the vital organs, the sensitive system doubly partakes of it, we have seen, through the central organs of the vital system and the sensitive nerves of the bowels. The more severe symptoms at first are in general only occasional; but, if no effectual means of obviating them be employed, almost always more or less increase in frequency, and some degree of them becomes permanent. The patient now feels relief necessary, and it is under such circumstances that he usually applies for medical assistance, at least in the physician's department of the profession.

It is evident, from what is said in the first part of this volume, how imperfect must be the view of the tendencies of this state of the disease, while the physiological errors which prevail in our profession continue to influence our views.

The brain and spinal marrow, supposed to be merely the organs of the sensitive system, are here the organs the functions of which are chiefly implicated; those on which the nervous fret induced by the disease of the digestive organs preys, and to

the state of which, if we look to the tendencies of the disease, our attention must be chiefly directed: and in its treatment we must never lose sight of the source from which it sprung, for if the source of the evil be allowed to remain, we in vain attempt to remove its consequences; and to this cause we shall find many thousands yearly fall a sacrifice in this country. From the nature and course of the disease being so little understood at present, its different stages are regarded as distinct diseases. The connection between the original debility of the digestive organs and the last and fatal stage of the disease not being understood, the former is generally lost sight of; the whole attention being engrossed by the last supervening disease, the consequence of the failure of function in the brain and spinal marrow; for these being the only organs which supply the nervous influence necessary to the existence of all our organs, when this supply is to a certain degree impaired, not only their functions, but, as we have seen, their structure also is endangered; and the function of any vital organ from other causes weaker than the rest then often begins to fail; and if the original cause is not relieved, the disease of function, in consequence of the central organs having been debilitated, soon runs into disease of structure, forming the last, and, if the history of the case has not been taken into account, the necessarily fatal stage of the disease.

In some instances the degree of suffering is very great; and what particularly points out its nature is, that this stage of the disease is often hastened by some other cause of nervous suffering concurring with that of the distended organs.

Anything which greatly affects the feelings, or any

effort which for a considerable time strains the mind, may, in concurrence with the disease, hasten on the stage I now speak of, or produce it when it would not otherwise have occurred; for the sympathy between the vital and sensitive organs, we have seen, is mutual. It is not uncommon in such cases to hear the patient say, the fretting which caused my present distress was what I suffered on such an occasion, or it came on after I had strained my mind by too severe application. But, being further questioned, he will recollect that he had previously some symptoms of indigestion, or of other chronic disease. When the first of these has been the case, I know, before I make the examination, that the liver is morbidly distended, and I never, under such circumstances, found it otherwise.

But whatever be the sufferings induced by this state of the disease, it is still free from immediate danger; and when it takes no other step, very severe suffering may continue for many years, as I have before observed, without any symptoms of immediate danger supervening. The only exception to this observation is, that those in this stage of the disease are liable to occasional attacks of bilious, often terminating in nervous fever; which, however, does not frequently occur, and is rather a tedious than a dangerous disease; but the next step in the progress of the disease before us always leads to danger, and, in many cases, of the most pressing nature.

On the second and last Stage of the Debility of the Brain and Spinal Marrow, being the third and last Stage of distended Liver.

We have seen, from the facts referred to in the first part of this treatise, that the brain and spinal marrow, so far from being merely organs of the sensitive system, as at present supposed even by the best informed of our profession*, supply an agent necessary to all the more complicated functions on which the existence, growth, and well-being of every organ both sensitive and vital depend; and it farther appears, from the facts there stated, that these organs, the brain and spinal marrow, are the only organs which supply that agent, namely, the nervous influence properly so called, which is conveyed from particular parts of the brain and spinal marrow by the nerves of the sensitive system, and from all parts of these organs by the nerves of the vital system; the powers of all parts of them being combined and applied by the ganglions, plexuses, and other nerves of the ganglionic system. So complicated is the nervous influence required for the functions of the vital organs.

If such be the facts, it is evident that any cause impairing the nervous functions, unless it be a local cause impeding the passage of the nervous influence through particular nerves, must have this effect through the brain or spinal marrow, or both. Thus all general failure of the nervous functions is referable to a debilitated or other morbid state of one or both

* See the quotation from Dr. Allison's Treatise given in the first part of this volume.

of these organs ; and we have seen it must be equally of both, when arising from causes affecting any vital organ, all of which influencing, as well as being influenced by, all parts of both. But as we have found that all the functions of assimilation, secretion, and excretion depend on the vital organs of the brain and spinal marrow, the healthy action of these organs cannot be impaired, whether by a local or general cause, without a tendency to failure in functions, which endangers all our organs, vital as well as sensitive; the former always directly, the latter either directly or through the vital organs. Such is the state at length induced by what have been called bilious complaints, understood in the sense above explained, that is, by a permanently distended state of the liver and duodenum, or long-continued chronic disease of any other organ after it has induced a general and permanent fret of nerves; an effect which always, and, from its nature, necessarily, more or less rapidly increases, if not checked by proper treatment, till the whole powers of the system are destroyed. I have never seen one case in which the efforts of nature removed, or even brought more than temporary and very imperfect relief under such circumstances, that is, after a general and permanent fret of nerves had once been established. Any organ which happens to be most inclined to disease, by the original laws of our frame, previous disease, or any other cause, will under such circumstances most readily suffer; and by its suffering, according to a well-known law of our frame, divert the effects of the general derangement from other parts.

The symptoms thence arising are the last train of morbid affections produced by a permanently dis-

tended liver; and this, we have seen, is the only way in which it proves fatal in our climate. It is in this last stage alone that the danger is immediate, but here it is often much greater than at first view appears.

As in most other diseases not arising from mechanical violence, the derangement of the organ last affected is at first only functional. But being now the most prominent part of the disease, it obscures the preceding symptoms, which are often in a great degree overlooked; and the more readily, that the supervening disease generally more or less relieves that which produced it; and if the practitioner be not aware of the nature of the state of the system which has previously debilitated the powers of life, he cannot be prepared for the rapidity with which the functional in such cases is often followed by structural derangement.

The disease I have been describing, we have seen, consists of three distinct stages.

The first is merely a distended state of the liver and duodenum, and generally slight derangements, chiefly of the alimentary canal, which accompany it; free from danger, and causing but occasional, and, in general, trifling local uneasiness.

The second stage is distinguished by a general and permanent fret of nerves having supervened, causing varied and often severe suffering, but still without immediate danger.

The third and last stage is characterised by an affection of some other vital organ, the brain and spinal marrow at length being so debilitated by the continuance of the nervous fret, that they are no longer capable of supplying sufficient nervous in-

fluence for the healthy functions of all the vital organs, and the organ most inclined to disease fails in its functions; and this failure soon runs to failure of structure, in consequence of the debility of the central organs. Here the suffering may be little, if at all, increased, and is sometimes alleviated, because the supervening disease often relieves many of the previous symptoms; but the danger, for the reasons just mentioned, is often great, of course greater or less according to the nature of the organ on which the disease fixes, the severity of the symptoms which last supervene, and the degree in which the vital organs of the brain and spinal marrow have been previously debilitated.

At different times of life different organs are most disposed to disease: hence it is that pulmonary consumption is frequently the fatal termination of distended liver in early life, palsy and apoplexy in late life; and wherever, after the fret of nerve has become permanent, there is any disposition, from whatever cause, to disease in any particular organ, the state of that organ should be watched with care.

Such are the nature and frequent course of the disease I have been describing, or of any other chronic disease of a vital organ of long continuance, which is little subject to change of structure. We have seen an instance of its arising from such an affection of the alimentary canal alone, and running through all its stages to the last fatal and rapid termination, although the usual course of distended liver seldom wholly arises from any affection of this canal. But as it is not only the most frequent of all such diseases, but there being no other organ in this country capable of such long-con-

tinued functional, without running to structural derangement *, and no other disease in this country is of so hereditary a nature as that which I have called distended liver; it proves the most frequent source of the succession of the diseased actions which has been described; and if we compare the frequency of its fatal termination with that of other serious diseases, I have no hesitation in saying it will, in our present plans of treatment, be found eventually one of the most fatal of all the diseases of our climate, although, under certain circumstances, the fatal termination is often long protracted. When to this we add the frequency of the slighter cases, and observe how much other diseases are modified by the influence of the liver, in consequence of its sympathising, to a degree that no other organ does, with the central organs of the vital, and, through the alimentary canal, with those of the sensitive system also, we have a correct view of the great importance of the liver both in creating and modifying disease; and need not be surprised that, in the countries where our sympathies are most active, all diseases, in whatever way they commence, if long protracted, terminate in affections of this organ, — a fact strikingly illustrative of all I have said on this part of the subject.

How comes it, it may be asked, if such be the facts, that they have demanded so little of our attention? The facts have not been overlooked; they are well known, and will at once be generally acknowledged. The correct inferences from them are what have been overlooked. They have not been so

* This is not the case in India and some other countries, in which the liver is peculiarly subject to disease of structure.

connected in the mind as to enable us to arrive at those inferences, because there was a necessary link wanting here, as in all other cases of this kind, in the chain of our reasoning. There has been all along, as appears from what is said above, a general feeling in our profession, that the brain and spinal marrow are organs of the sensitive functions alone, and we have, therefore, looked to them as influencing disease no farther than it is found to be influenced by these functions. We are not aware that nervous irritation, long supported by a cause however in itself of little importance, is tending *directly* to impair the vigour of the organs of the leading power in the vital system, with the failing powers of which the vigour of all other organs must fail. By a knowledge of the facts here referred to, we are enabled to compare the ultimate with the immediate effect of causes which, in their early effects, appear so trivial; and when the former show themselves, by tracing them to their source, clearly to perceive the course we must pursue to obviate them: for it will ever be vain to attempt the cure of a disease, if the cause which produced it be allowed to operate, particularly when the cause exists in our own frame, and from its nature is by habit, except as far as it is relieved by the supervening and more fatal disease, every day, while overlooked, gaining additional power.

Such are the circumstances which give to functional disease of the liver an importance which at first view appears little to belong to it, and which, in an early stage of my practice, turned my mind to a careful observation of its effects; for it is now more than five-and-twenty years since I was aware that

the leading power in the vital system originates in the brain and spinal marrow; the proofs of which were long ago laid before the Royal Society of London, which did me the honour to *republish* them in a connected form, in their Transactions for the year 1836.

The intelligent reader will perceive by what has been said, that the importance of the liver, in the cases before us, does not arise from the frequency of the foregoing affection of it alone, but on this, together with the liver being possessed of those properties, which more than any other organ fit it for laying the foundation of such a train of diseased actions as has been detailed. It is of all our vital organs the most subject, in this country, to chronic debility, and, with the exception of the brain and spinal marrow themselves, of more extensive influence with respect to other vital organs, than any other of our frame, and the least of all those organs, in such climates as our own, subject to change of structure from such functional disease as is capable of producing the effects above enumerated. Thus we find it possessed of all those qualities which we have seen tend, by its chronic affections, to produce a debilitated state of the central organs of the vital system.

On the supervening local affection which characterises the last, and at present generally fatal, stage of the disease, I am now to make the necessary observations, in order to prepare us for entering on the treatment of this stage.

As, in treating of the first stage, I selected the distended liver as the most frequent cause of the class of diseases we are considering, and the observations it was necessary to make respecting it are

more or less applicable to any other similar affection occurring under the same circumstances, and having the same tendencies; I shall, in like manner, in considering the local affection which characterises the last stage of the disease, select that in which it most frequently terminates in these kingdoms — pulmonary consumption; and many of the observations which apply to it will be found more or less applicable to any other affection of a similar origin, that is, occurring under the same circumstances.

Another reason for the selection of this disease is the vast difference in the nature, and, consequently, the tendencies of the original and symptomatic affections of the lungs, which has attracted too little attention.

The circumstances which, in pulmonary consumption, render the distinction between the original and symptomatic disease doubly important, are, that the former is often an incurable disease from the commencement — so little is the power of our remedies over the original affections of the lungs; while, in almost all cases, the latter can be arrested in its early stages, and often in all stages previous to the structure of the lungs being actually diseased, which in most cases occurs at a later period of the symptomatic than idiopathic affection; and for every case of the original disease in these kingdoms, we meet with at least twenty, but, according to my experience, many times more, of the symptomatic.

It also deserves attention, that the latter is that in which the hereditary predisposition is by far the most powerful cause of its greater frequency. I have never in a single instance known two members of the same family fall a sacrifice to the original disease,

while I have seen almost whole families swept off by the symptomatic form — that form, although as certainly fatal as the other, if the structure of the lungs has been allowed to become seriously diseased, but which, in its earliest stage, is, I believe, always curable. A most gratifying proof of this is, that I have had the satisfaction of seeing in many families, in which one after another had fallen a sacrifice to symptomatic phthisis, its ravages wholly and finally prevented; and that by means of easy application: so that there is reason to believe that when the proper treatment becomes general, as this form of consumption is by far the most frequent, the disease which at present destroys annually so many thousands in these kingdoms will be comparatively rare.

It is a striking fact, and shows how essentially different is the nature of these cases, that in the extensive practice of between thirty and forty years, I have never seen the two forms of the disease in the same family.

I can even go farther than this, for I cannot recollect one instance of the original disease of the lungs having appeared in two individuals of the same family. According to my experience, it cannot therefore be regarded as an hereditary disease. Nor, according to that experience, can the common form of the disease be strictly regarded as such, because, as it only appears in the symptomatic form, and is uniformily averted by preventing the original disease, which therefore appears essential to its production, the disease itself hardly deserves the name of hereditary.

There can be no doubt of a weakness of lungs being hereditary; but if the circumstances just stated

be correct, and I have witnessed them too often for a doubt to remain on my mind, this weakness of lungs will only produce pulmonary consumption when other circumstances concur with it; and these circumstances are generally under our control in this form of the disease, although, when the structure of the lungs has been allowed to become seriously injured, it is as fatal as that which originates in the lungs themselves. I believe it may almost always, from my own experience I would say always, if it does not arise from a settled grief which cannot be removed, be arrested at an early period.

My experience has furnished me with no other case which is beyond our control, if the proper plan of treatment be adopted from the commencement of the disease. Here the debility of the central organs of the sensitive spreads to those of the vital system, and thus debilitates the vital organs of the brain and spinal marrow as any other continued fret of nerve is found to do.

It will appear from all that has been said, that it is the functional, not organic, affection of the liver, which lays the foundation of the symptomatic pulmonary consumption of which I speak. The organic affection of the liver is too evident a disease to be disregarded; and when disease of structure has taken place in the liver, no well-informed physician can be misled respecting the nature of the disease. It is when the affection of the liver continues merely functional, but lasts till it establishes a permanent fret of nerves, which, if there be no original debility of the nervous system, generally requires the continuance of some years, that it produces the symptomatic affection of the lungs I now speak of.

This circumstance has tended to confirm the error which has prevailed; because, according to a law of our frame which I have had frequent occasion to refer to, the original disease, when only functional, is generally relieved by the secondary disease, even when it also is functional; but when the latter has become structural, it never fails to relieve, and very often wholly removes, the functional disease from which it sprang. From this cause many finding on dissection that there had been only functional, if any, disease of liver; and organic disease of the lungs; have been confirmed in their erroneous view of the case, by the liver bearing little or no marks of disease.

We have a memorable instance of this error in the post-mortem examination of the late Dr. Currie, a man both of talents and correct observation, and who had long laboured under symptoms of distended liver, and regarded all his complaints as originating in them. But those who made the post-mortem examination having reported the liver to be quite sound, but the structure of the lungs destroyed, it has been generally supposed that he had mistaken his own case. He could not have been mistaken in this, that he had been long distressed by bilious irritation; and we can have little doubt the mistake imputed to him was the consequence of the fact just mentioned. There being no trace of disease found in the liver after death, was no proof of the disease of the lungs not having originated there, the first stage of the disease in such cases being merely a distended and consequently debilitated state of the ducts and other vessels of the liver.

Unless the symptoms of disordered structure of the lungs are unequivocal in the cases we are considering, however in other respects alarming the

symptoms, experience has taught me never to despair, unless all morbid distention of the liver having disappeared, this organ has retired into its proper position under the ribs; for I have in a few instances seen recovery by the means I am about to state, where at first view the case appeared to be hopeless. But the affection of the liver being completely removed, without having afforded relief to the pulmonary symptoms, I have, as stated in my Treatise on Indigestion, uniformly found a fatal symptom.

In general, the symptomatic phthisis, partaking of the nature of the disease from which it springs, which, for the reasons above explained, must always be a chronic disease, is usually slower, as I have already had occasion to observe, in running to diseased structure than the idiopathic form of the disease; but when, in the case before us, the fret of nerve has been such as more suddenly than usual to debilitate the central organs of the vital system, it often rapidly assumes an alarming character.

Even where there is no peculiar weakness of lungs, or of any other vital organ, they often suffer merely from their being the organ, particularly in the period of youth, by the constitution of our frame, most inclined to disease; an observation well illustrated by the tendencies of advanced life, in which the brain becomes the organ most liable to disease: and here any cause of long-continued fret of nerve, by whatever means produced, terminates most frequently in palsy and apoplexy, and I can say from long experience that this, in advanced life, is among their most frequent causes.

On reviewing all that has been said, it appears that in our own climate we can trace the same extensive

influence of the vital sympathies of the liver which we have seen, from the more active state of our sympathies, are so much more remarkable in sultry climates; and where their effects are rendered more powerful by the greater tendency in such climates to organic disease of this organ, which causes it, as it were, to monopolise the diseases of such climates, particularly of the East Indies; for let disease in the first instance be of what nature it may, it almost always, if it assumes a permanent form in India, terminates in diseased liver; the best illustration of what has been said of the extensive sympathies of this organ, and which at once explains to us the well-known risk to Europeans of indulging in such climates in the free use of fermented liquors, and particularly distilled spirits, which in all climates is a powerful cause of disorganised liver. It is fortunate for the inhabitants of our own climate, that the disease of this organ, so prevalent in it, is of a milder nature, and I believe in those of regular habits always removable, even after some of its more serious consequences have begun to show themselves: and were this the proper place for such a discussion, it would be easy to prove that the same extensive sympathy with other vital organs appears in the symptomatic as in the original affections of the liver; for there is, even in this country, no serious disease in which its state can be safely disregarded. The same cause which renders it so liable to partake of other diseases, enables it powerfully to influence their course.

On the Treatment of the first Stage of Debility of the Brain and Spinal Marrow, being the second Stage of distended Liver.

We are now to consider the treatment of a debilitated state of the brain and spinal marrow, arising from the causes enumerated in the two preceding divisions.

Without entering particularly into the treatment of the first stage of distended liver, that stage which always precedes the establishment of this disease, consisting of occasional fits of indigestion, sometimes accompanied with more or less temporary distention of the liver, for the treatment of which I refer to the seventh edition of this Treatise, which is not yet out of print; I shall here enter at once on the more important disease, when, from the frequent recurrence of temporary indigestion and a debilitated and consequently distended state of the liver, this affection has become permanent; and point out the causes which have hitherto rendered the treatment so little efficacious, in what I call the second stage of distended, that is, the first stage of permanently distended liver; in which, after a certain degree of relief is afforded, the patient is desired to attend to the rules of diet we lay down, regulate the bowels by the means we have pointed out, think as little as possible of his complaints, and have recourse to a dose of calomel when he feels more indisposed than usual; and thus he is dismissed, more or less an invalid for life, even if the last stage does not supervene. I have said, however, that under such circumstances a cure may almost always

be effected, and that, if the disease be allowed to run its course, the result, however delayed, if the patient be not carried off by other causes in the meantime, is certainly fatal, and that after severe and generally long-continued suffering. I shall here point out what, as far as I can judge, have been the causes which have prevented the permanent cure, in all cases of long standing; and the principles on which repeated experience has assured me that such a cure may be effected.

It appears from what is said in the first part of this Treatise, that the brain and spinal marrow are capable of influencing, and being influenced, by every part of the more perfect animal; or, in other words, that every part of the brain and spinal marrow on the one hand, and every other part of our frame on the other, may each through the other be more or less excited, or more or less debilitated according to the nature and degree of the cause which operates, and the nature and functions of the parts operated on. The effects are of course more or less felt, according to the sensibility and more or less extensive sympathies of the part on which the impression is made.

We found that of all our organs those of digestion, being some of them the most sensitive and others of the most powerful and extensive sympathies, most influence the brain and spinal marrow. Their morbid affections thus become the most powerful of all this class of causes in debilitating those organs.

Such were the circumstances which led me, in considering the effects of a permanently debilitated state of the brain and spinal marrow, to choose the case in which the offending cause exists in the digestive organs, as an example of all cases of the same nature.

The manner in which the state of the digestive organs here referred to commences is always the same as just mentioned, that is, by occasional recurrence of fits of indigestion which at length become permanent, gradually inducing a corresponding and equally permanent failure of function in the brain and spinal marrow, which we have seen often proves the source of some of the most fatal diseases to which we are subject.

I shall not enter on the treatment of what is called indigestion, which forms the first stage of distended liver, in which, if any sensible distention of the liver can be perceived, it is only occasional, generally in this country arising from temporary disorder of the stomach, and disappearing when the due action of the stomach is restored; but the frequent recurrence of which at length produces the permanently debilitated and consequently distended liver.

The treatment of the temporary disease is well understood, and generally for the time successful.

Here I shall confine myself to the more important stages of distended liver, in which, the attacks of indigestion having been permitted to recur, they have produced a permanent debility of the digestive organs, namely, the stomach, liver, and the bowel into which the stomach discharges the food, after it has undergone the changes produced by the juice prepared by the stomach itself.

In treating of the nature of indigestion, I have already had occasion fully to consider its diagnostic symptoms when confirmed by habit; in which state, we have found, it differs almost as much in its nature and consequences, from the occasional attacks of

indigestion with which it has been confounded, as any disease can differ from another. By these diagnostic symptoms we can not only always distinguish confirmed indigestion from all other diseases, but accurately, at all periods of the disease, determine its degree and the various changes which take place in the course of the treatment, which is particularly necessary in a derangement which strikes at the very root of all the powers of life, and without which it would have been impossible that the treatment could have been correctly conducted, and consequently its permanent success secured.

It is equally necessary, in conducting the treatment, constantly to have in view the only fatal termination to which it leads in these kingdoms, namely, the supervention of disease in some other vital organ than any of those which suffer in its early stages; for the functional disease of the liver, in which all its more serious consequences originate, never, in them, becomes a disease of structure, as it is apt to do in sultry climates, and particularly in the East Indies; but when the powers of the brain and spinal marrow, as we have seen, are to a certain degree permanently impaired, all the vital organs, depending for their functions on the influence supplied by them alone, being endangered, that most prone to disease yields, and from their powers having been long debilitated, the supervening functional disease, for it is always only functional at first, rapidly runs to disease of structure; and thus the physiological errors which have prevailed in our profession having tended to prevent our attention being called to the early and curable stages of the disease, and consequently to the origin of the last

and fatal stage of it, on the correction of these errors the more successful treatment depends; which is immediately founded on our thus acquiring the knowledge that the disease from which, in this stage, the danger immediately arises, is a secondary, not a primary disease, in consequence of which a due attention to the affection which is the original cause of that which last supervenes, and is now the most prominent disease, is equally necessary both to its prevention, and, when it has supervened, to its cure.

It is stated in my Treatise on the effects of minute doses of mercury, that, if this last stage of the disease is not essentially relieved by the removal of the distended state of the liver, it proves that our means of cure have been too long delayed, and in every such instance I have found the disease fatal; a result uniformly confirmed by my additional experience since the publication of that Treatise.

As soon as the distended state of the liver has become permanent, the healthy functions of the brain and spinal marrow are endangered, an equally permanent debility of these organs being threatened; but the period required for this step in the progress of the disease, as appears from what has already been said, is necessarily very various, according to the constitution of the patient, and the circumstances in which he is placed. The stronger the nerves, and the less the patient is exposed to other causes, in addition to his disease, tending to produce fret of nerves, the less apt is this state to be established. It is very rare for a permanently distended liver to produce a permanent fret of nerves in less than two or three years, and in those who possess great vigour of nerve even a longer time is required; but whatever be the

time required for this effect, it is always a state of permanent and often severe suffering, and is uniformly attended with a more or less rapid decay of the powers of the brain and spinal marrow, which is no less a certain consequence of the establishment of a permanent fret of nerve, than the morbid distention of the liver is of a debilitated function of that organ.

The decay of the powers of the brain and spinal marrow may be divided into two stages; the second, in the present state of our profession, a necessarily fatal consequence of the first.

It appeared to me that a principal cause of our failure in the cure of permanently distended liver was our trusting the cure to doses of mercury, the only medicine on which we can rely in affections of that organ, of such amount as could only be given at considerable intervals, that of two or three days, without rendering the effects of the medicine almost as pernicious as the disease; in consequence of which, the bile more or less accumulating in the interval in the debilitated liver, and the effect of our doses being thus only temporary, the permanent cure was impossible. Another circumstance which of itself would have rendered a permanent cure, in many cases of long standing, impossible, even under the most efficient administration of mercury, is, that we overlooked a common consequence of the impaired function of the stomach, which, we have seen, in the majority of cases more or less attends it, the continuance of the irritations of indigestion producing an inflammatory state of the parts most exposed to them, which I found, from many post-mortem ex-

aminations, always first takes place in the pylorus, that is, the orifice which connects the stomach with the bowels, (which, in those who had long suffered from disordered digestion, was often found as red as if it had been actively inflamed,) and this inflammatory state is apt to spread more or less to neighbouring parts, and particularly to the left edge of the liver, and also, though less frequently, to other parts of the stomach ; but it always, as far as I have seen, retains its chronic nature. I have never seen one instance of its changing to acute inflammation, nor is the patient ever sensible of its existence till pressure is applied to the parts affected ; chronic inflammation, although never attended with pain, always causes a tenderness on pressure, to be felt in the region of the parts affected, and prevents the proper effect of our remedies. In the least inflammatory habits this tenderness does not always occur ; but I can say from extensive experience, that where it does, which, we have seen, is in a large majority of cases, its continuance obviates the effect of our treatment even to the extent of rendering the removal of the disease impossible. All inflammatory tendency binds up the surfaces, whereas the object of the treatment here is to relax them ; for such is the sympathy of the liver with all other parts of our frame, that the bile will never flow with freedom unless the surfaces in general are free ; and a free state of the skin and bowels in particular is requisite to the free action of the liver. Such is the power and general nature of its sympathies, that the proper treatment, particularly of its more chronic affections, includes an attention to the state of the general habit, and particularly of those parts with which its sym-

pathies are most powerful, the skin and bowels, the former of which is apt to become, in obstinate cases, not only dry, but almost horny, the nails becoming brittle and often cracked.

With respect to the first of the foregoing causes which have rendered our practice in distended liver, if of any standing, so inefficient, it occurred to me, above five-and-twenty years ago, that as we cannot give the usual mercurial doses except at long intervals, during which, in such cases, their effects are in a great degree obviated, some means must be found to maintain these effects during the intervals, before we can make effectual progress in removing the disease.

I tried dandelion, ipecacuanha, and other means, which have some power in exciting the liver; but none had any effect at all to be depended on, till I had recourse to minute doses of mercury, given at intervals of eight hours. The dose I found after many trials to answer the purpose was either the twentieth part of a grain of calomel, or half a grain of blue pill, which as an alterative is equal or nearly equal in power to it, according as the one or other best suited the constitution. The minute dose of calomel is most aperient, but, on the whole, I have thought that the blue pill is the best alterative.

There are many circumstances to be observed in their employment, which have gradually shown themselves, and many of which are stated in my Treatise on Minute Doses of Mercury. Their good effects, however, are not to be wholly ascribed to their keeping up the effect of the larger dose, which must always be continued under their use, for they have

little effect in enabling the liver to discharge the accumulated bile. In proportion as this becomes less, the larger dose may be employed at longer intervals, and in all cases it must be so carried off as to prevent its entering the system.

One of the greatest defects in our present plans of treatment is, that, no correct line of distinction having been drawn between the vital and sensitive functions, which was hardly possible till a knowledge of the agent on which the powers of the nervous influence properly so called depend was ascertained, so that its functions could be clearly, in all cases, distinguished from the functions of the sensorial power properly so called, with which some even of our best physiologists have confounded them ; it was not likely that the attention of the practical physician could be effectually directed to the degree required in the regulation of some practical points of essential importance in the differences of the laws which regulate the sensorial, that is, the sensitive system, and those which regulate the nervous system properly so called, — a system whose functions, we have seen, wholly depend on one of the agents of inanimate nature, the effects of which in the living animal prove that it is still more justly than we supposed termed the most universal of all agents. The consequence of which has been that the practical physician has paid little attention to the differences here referred to; in many cases an attention to which is essential in the cure of disease: one of the most important of these differences in a practical point of view is, that while in the sensitive system, we have seen, all degrees of excitement however slight produce proportional exhaustion, in the vital system, they only have this effect when the

excitement exceeds that required for the healthy function of the part.*

Thus it is that, in this system, whatever produces the stimulant effect within that range in any vital organ, supports its function without any sensible subsequent depression, and thus acts as a tonic on that particular organ. I have found that such is the effect of the minute mercurial dose. While the excitement of the larger dose is followed by a more languid action of the liver, the minute dose, supplying a constant and gentle stimulus within the limit which produces corresponding depression, acts as a tonic, and the organ gradually and uniformily recovers its power under its use; and in permanently distended liver, the whole system, the debility of which depends on that of the liver, experiences a corresponding effect: and I can say that I am unable to recall one case, where there was no disease but the distended liver and its consequences, however long it had lasted, provided no other organ was so affected as to threaten disease of structure, and the patient did not become tired of the means, — for in cases which have been long protracted the recovery is necessarily slow, — in which he was not restored to permanent health; and I can at this moment point out cases which had lasted for more than twenty years, in which the patient for many years past has enjoyed uninterrupted health, where all former means employed by the most experienced and skilful physicians had been employed in vain. As the minute dose alone is allowed to enter the system, none of the bad effects of a course of mercury, however long continued, attend its use.†

* Philosophical Transactions for 1836.

† See my Treatise on Minute Doses of Mercury.

By discontinuing this dose as soon as any tenderness of the gums is perceived, the patient being directed to brush the teeth at least once every day, all risk of salivation is prevented, which, although generally necessary to the cure in confirmed diseased liver, I have always found injurious in the case before us.

With respect to the tenderness on pressure of the parts chiefly concerned in the disease, the removal of which, for the reasons just pointed out, is essential to recovery after the liver has become permanently distended, the only means of its removal which I for a long time employed, was blood-letting from the parts of the skin in their immediate neighbourhood, provided the repetition of the evening dose of calomel, which is always freely carried off in the morning, failed to remove it, which it does in the most favourable cases. The patient is never sensible of this tenderness, as it occasions no uneasiness, except on pressure in its seat; it is therefore always overlooked, if the physician does not detect it by an examination of the parts affected, and while it is so, recovery is impossible. All tenderness on pressure must be removed before the liver can be made thoroughly to empty itself.

Often-repeated local blood-lettings are frequently required for its removal, so frequently in some cases, that I found it necessary to look out for other means of its removal, for I have seen it resist fifty repetitions of the cupping, which I have always found the most effectual mode of local blood-letting. It is that also which is most easily regulated. By it the process is of short duration, and we can accurately ascertain the quantity of blood taken. The blood must always be taken from the most tender part, which in the com-

mencement is the region of the pylorus. It is remarkable that there was not an anatomist in London who could point out to me the part of the skin under which the pylorus lies; and the late Mr. Brooks was good enough to use one of the bodies in his dissecting room for the purpose of ascertaining this part, which we found to be the soft part close to the left edge of the ribs on the right side, just before they turn away to that side.

I was so fortunate as to find the means I first had recourse to, where local-blood letting had failed, even more successful than I expected; for I have not only never met with one case in which the tenderness on pressure resisted it, but, in addition to this effect, it has always contributed towards removing the morbid fulness of the hypatic region, by decidedly promoting the return of the liver to its healthy position under the ribs. The remedy I speak of is a seton placed in the region of the pylorus, that is, in the original and chief seat of the tenderness on pressure. Nor is this so troublesome a remedy as at first view it may appear, because it is seldom necessary to allow it to remain long enough to form such a habit as makes any precaution necessary in removing it. The following is the practice I now pursue respecting this most important symptom.

In some, in whom the tendency is slight, it yields in ten days or a fortnight to the larger doses of calomel, which are for other reasons necessary; more frequently, to a few repetitions of local blood-letting from the region of the pylorus. When it resists these means, I advise a seton to be placed in this region, on the efficacy of which, although its beneficial effects

are generally slowly produced, I have hitherto always had reason to depend.

Although the tenderness never assumes the form of active inflammation, it is sufficient to bind up the surfaces; and as our means must always be of the gentlest nature, (for what is called a course of mercury is capable of causing, and cannot therefore remove, the disease,) their effects are easily counteracted. Along with the foregoing means some stomachic medicine is proper; for grateful as mercury is to the liver, to the stomach and bowels it is more or less offensive; but tonics, properly so called, can seldom be employed without injury, and never till all inflammatory tendency is subdued.

When all disposition to tenderness on pressure is removed, or, in cases where it has never supervened, if the distended state of the liver does not readily yield to the foregoing means, great advantage is obtained by combining with them the use of voltaic electricity, employed in the manner and with the precautions I have pointed out in the seventh edition of my Treatise on Indigestion.

Such, with the means of relieving occasional symptoms, which are very various, depending on accidental causes and peculiarity of constitution, is the general outline of the treatment which I have found successful in effectually removing habitual distention of the liver, which, although itself unattended with danger in this country, where, we have seen, the liver never runs to disorganisation from this cause, except in drunkards, has, as appears from the consequences of its continuance, above stated, too little attracted the attention of the medical profession.

On the Treatment of the second and last Stage of the Debility of the Brain and Spinal Marrow; being the third Stage of distended Liver.

I have, in the preceding part of this volume, stated my reasons for making choice of the distended liver as an example of those chronic diseases which prey on the brain and spinal marrow, the only organs, we have seen, which supply the nervous influence which is essential to all the more complicated vital functions.

By the different processes effected in the stomach and duodenum, the reader has seen, our food is converted into a fluid called the chyle, which, being taken up by the absorbent vessels, distributed throughout the remaining parts of the alimentary canal, is conveyed into the mass of blood, and thus supplied to the various assimilating organs, that is, to all the organs of our bodies which admit the circulating blood; for they all possess the assimilating power, the power of converting the fluids supplied by the circulation into the substance of our bodies, derived, we have seen, from the nervous influence supplied by all parts of the brain and spinal marrow, and combined and applied by the powers of the ganglionic system and its various nerves.

It is evident, therefore, that any failure in the supply of the agent which both completes the digestion in the stomach and duodenum, and is that which converts the digested food into our various organs, must endanger all these organs whether sensitive or vital.

Under such circumstances, that organ which hap-

pens, from previous disease, hereditary disposition, period of life, or any other cause, to be most liable to disease, yields ; and, according to a well-known law of our frame, particularly with regard to diseases of structure, acts more or less as a preventive with respect to other diseases ; and as, on account of the great frequency and importance of distended liver in this country, I have chosen it as an example of those chronic diseases the continuance of which debilitates the brain and spinal marrow, I have also pointed out my reasons for choosing a certain form of pulmonary consumption as an example of the diseases which supervene when the powers of the vital organs of the brain and spinal marrow have so failed that they can no longer supply the nervous influence necessary for the healthy maintenance of all the vital organs.

The following observations, then, apply to hereditary pulmonary consumption, in consequence of its always being a secondary disease ; while the pulmonary consumption which originates in the lungs themselves is of a very different nature, rarely occurring in this country, and requiring, we have seen, a very different plan of treatment. But whether the secondary consumption is or is not hereditary, it still requires the same plan of treatment, for the same secondary form of this disease may arise without any hereditary disposition, although this is much less frequently the case. Whether there be an hereditary disposition to weak lungs or not, the permanently distended state of the liver is, in these kingdoms, the cause of the pulmonary disease in at least nineteen cases out of twenty.

When I first experienced the advantage of what I believe to be the only treatment capable, in such cases,

of restoring tone to the digestive organs, I had no idea that this debility of these organs formed any part of the cause of the affection of the lungs. Nor was I convinced of this till I found, from many cases, that, on the one hand, in every instance in which I succeeded in restoring permanent vigour to the digestive organs, and where the affection of the lungs had not gone so far as to produce disorganisation, or so strong a tendency to it that there was not time for the necessary treatment, the consumptive symptoms wholly disappeared; and that, on the other hand, I never met with any case of pulmonary consumption, except that which originates in the lungs themselves, and which I have ascertained to be a disease of a wholly different origin from the common consumption of this country, never being either symptomatic or hereditary, which did not yield to what I consider the proper treatment in the secondary disease, if employed at an early period.

Where the first deviation from a state of health is in the lungs themselves, the only powerful means of permanent relief, if the disease be far advanced, is an immediate change to a warm and more steady climate. This form of the disease is so far from being hereditary, that in more than thirty years' extensive practice, in which my attention has been directed to the subject, I have never seen two cases of it in the same family, nor have I ever in one instance seen the two forms of it in the same family; and so rare is the species which wholly originates in the lungs in this country, that, according to my experience, which it will appear from what has been said has long been extensive, a physician may be in general practice for several years without meeting

with a case of it; while the symptomatic consumption is one of the most frequent diseases which comes under his care; its hereditary form, which is always symptomatic, being, certainly by many degrees, the most frequent.

It most unluckily happens that, in this disease, the physician is not in general applied to till the case is too far advanced to admit of recovery; and the only instances in which the proper plan of treatment has been universally successful are those in which the family, having been taught by former experience, has adopted the proper treatment from the commencement of the disease; and thus many of the most consumptive families of this country have, as has already been observed, been wholly protected against its fatal effects; for it is a remarkable and most important fact, that I have never found any more difficulty in finally stopping the disease in the commencement by the treatment I am about to point out, than in curing a common cough in families which are not at all consumptive. It is only necessary to combine the usual means of allaying cough from cold, in a non-consumptive family, with the means of removing the original affection from which the symptomatic part of the disease arises; nor can I recall one case in which I saw the patient, even within a month from the commencement of the cough, in which the cure was not permanently effected; and thus many of the most consumptive families have been as certainly secured against the fatal effects of the disease, as if no particular tendencies to it had existed in their constitutions.

I HAVE just had occasion to observe that the cure of this complicated disease consists wholly in a com-

bination of the present treatment, by which the symptoms are mitigated, and, at an early period, sometimes removed ; for we can in all cases observe more or less of the effects of what has been termed the *vis medicatrix naturæ*, which, when the symptoms are relieved at an early period, will often itself complete the cure ; but this should never be trusted to in the case before us, which requires the most careful employment of all our means to ensure success. From the great frequency of pulmonary consumption in this country, we have had ample means of determining the treatment which tends to alleviate its symptoms. In the species of this disease which I am now considering, it is necessary, in order to secure recovery, to combine those means, modified in the way I am about to point out, with such as control the morbid affection from which it has arisen, the cause which has been preying on the brain and spinal marrow ; for unless this cause, which has produced and still supports the disease, can be removed, there are no means by which, after a certain period, we can arrest its progress ; and the result of the whole of my latter experience, which has been extensive for thirty years, is, that unless this can be done before any actual disease of structure has occurred in the lungs, our attempt is vain. We ought never to despair while there is reason to believe that the structure of the lungs is still entire. It is to be recollected, however, that the cure of the original disease is always tedious ; and although, in almost all instances, the symptoms show a tendency to yield as soon as the original disease is relieved, if any change of structure in the lungs has in the mean time taken place, they again increase, I believe always in this form of the disease, and prove fatal ; that is, when it

is a secondary disease, which, as just observed, as far as my observation has gone, is always the case with respect to the hereditary pulmonary consumption of this country; and the same observation applies to all other cases of pulmonary consumption when it is a secondary disease, and it is of this nature in these kingdoms in at least nineteen out of twenty cases. The disease that originates in the lungs themselves, we have seen, obeys different laws; and we have reason to believe that a proper change of climate will often arrest the progress of this form of the disease, after the structure of a certain portion of the lungs has become so diseased as to be incapable of its function. A little reflection will show why this can never happen in the secondary disease, depending on debility of the brain and spinal marrow, in which recovery, we have just seen, cannot, with any certainty be promised, if thecough has continued above a month, although, if no decidedsymptoms of organic disease of the lungs have appeared, it generally takes place at much later periods.

If, in short, the proper treatment be adopted as soon as the cough is established, I always promise recovery, and cannot recollect one instance in which, when this was the case, however strong the hereditary disposition, my prediction was not verified; and, as stated above, I have thus wholly banished pulmonary consumption from some of the most consumptive families in this country. It is only necessary, in such families, never to allow even the slightest cough to establish itself; and I have always found, even in such families, that the cough readily yields in the commencement, provided proper and decided measures are taken to relieve the distended liver, or other

cause, from which, being always a secondary disease, it originates. The only certainly fatal case from the beginning of this species of pulmonary consumption is when it arises from settled grief, which we have not the means of removing, — a cause which always operates in the same way as the distended liver, by producing a debilitated state of the brain and spinal marrow, and well illustrates the manner in which the distended liver operates, — while we employ the ordinary treatment for the relief of the cough, which consists merely in a proper selection of quieting medicine, and the necessary attention to the general state of health.

A good deal of care is required in the selection of the quieting medicines best adapted to such cases, for all powerful opiates, in the case of distended liver, tend to confirm the original disease, of which if we lose sight, the case, after it has arrived at a certain stage in consumptive families, is necessarily fatal.

There is, as far as I know, but one quieting medicine of such power as to make it necessary to mention it, which has little or no tendency to confirm and increase the distended state of the liver, —I mean henbane; and although, where the patient is particularly sensitive to the bad effects of other opiates, it may be proper to make a trial of it, we rarely find it of sufficient power, in doses that are not otherwise objectionable, to allay the cough.

On the whole, the opiate I have found the best in such cases is the extract of poppies, which is much less apt to obstruct the liver than any preparation of opium itself; but, like the henbane, it is deficient in quieting power; and after a trial of various combina-

tions of sedatives for the purpose of allaying the cough in such complicated cases, the result of the experience of more than thirty years is, that I prefer to other sedatives the extract of poppies, always using this alone in the first instance, and if not itself sufficiently sedative, combining it with minute doses of opium, carried no farther than is necessary for preventing the harassment of the patient by the frequency and severity of the cough; for the mere act of coughing is less injurious than is generally supposed. The most violent coughs are often the safest. The safest of all coughs, if inflammation does not supervene, is the most violent — the hooping cough; but in all cases of pulmonary consumption, whatever tends to harass and reduce the strength should be carefully avoided. The rapidity of this disease is generally in very exact proportion to the loss of strength. From its inflammatory nature, however, and the circumstance that almost all powerful tonics tend to increase the distention of the liver, it is necessary to be very cautious in the use of tonics. I know of none of much efficacy that we can venture to employ in such a case.

The creosote (for, where it agrees, it certainly deserves the name of a tonic) is the only one I now employ in the case before us, and if it neither at all oppresses the stomach nor produces headach, I have found no bad effect from it in such cases; and in general, where it agrees with the patient, it tends sensibly to support the strength. I generally begin with from five to eight minims, rubbed with mucilage, and sufficiently diluted to prevent any unpleasant heat in the mouth or throat in swallowing it, and have gradually increased the dose to several times this quantity,

when I found that it produced neither of the effects just mentioned.

But of all the means of cure in the case before us, that which requires most attention is the employment of the mercurial. I shall here make such observations on this part of the treatment as are necessary, in addition to what has been said on it.

On comparing all that has been said, it is evidently necessary, in the last stage of debility of the brain and spinal marrow, in the case before us, to do all which the patient's state admits of to accelerate the removal of the original disease; and this is in no case more necessary than where the supervening disease is seated in the lungs.

It is of essential consequence, as explained above, that the practitioner who directs the treatment in the case we are considering, should have the means, not only of correctly distinguishing the distended liver from any structural disease of the liver, but also, at all periods of the treatment, of determining at what rate the disease is yielding, and when the morbid distention is removed. I would always recommend the patient, however well he may conceive he understands what is said in the present treatise, to place himself under the care of a medical attendant when he can.

It is always of great consequence in the treatment of disease to consult with a person in the habit of attending to the various details of practice, however well the patient may himself understand the principles of the treatment. At the same time, I have endeavoured to make my language so plain that those out of the profession, I hope, may tolerably well regulate the treatment where a professional man cannot be obtained.

The part where the fulness is most perceptible on pressure is a little to the right side of the hollow, called the pit, of the stomach, and near to the edge of the ribs, after they divide at the pit of the stomach, and a little above the place where the ribs suddenly turn away to the right side, after they have been gradually sloping to that side more or less in different individuals. The distance to which the morbid fulness extends below the ribs, on comparing the two sides, is the measure of the distention the liver has undergone; for a perfectly healthy liver, we have seen, lies entirely under the ribs, and cannot, therefore, be perceived by the hand of the examiner; and it will be found that just in proportion as the symptoms of the disease yield, the fulness occasioned by the distention of the liver disappears.

As there is no disease of structure, there is no induration to be felt; we therefore look in vain for the hardened edge observed in schirrous liver; we feel only a general fulness of the part; and the degree of this, as above pointed out, is best felt in the erect position, because in this position the liver comes most forward; whereas in indurated liver we judge best of the state of the disease when the patient lies on the back, because in this position the intervening muscles between the hand of the examiner and the liver are most relaxed, and we can best judge both of the degree and extent of the induration of the liver. I have never seen the distended liver extend as the schirrous liver sometimes does, so as to fill more than half the abdomen, displacing a great part of the other abdominal viscera. I have seen the latter occupying more than two thirds of the whole abdomen, whereas the former

I have never found descending more than three or four inches below the edge of the ribs; nor have I ever seen it extending to the left side so as much, if at all, to displace any of the other viscera. Indeed, this is hardly possible, both on account of its retaining all its natural softness, as well as the mere distention of the organ never taking place to the degree which often occurs in disorganised liver. The natural structure of the liver does not admit of such distention. In every case of distended liver I have seen, we could perceive the line of distinction between the distended liver and distended duodenum, which we have seen is always the consequence of its continuance, while I have seen the indurated liver not only extending far below the navel, but also to the left side, displacing every thing which opposed it, no degree of which I have ever seen in distended liver.

The fulness of the region of the liver is generally, not always, we have seen, attended with tenderness on pressure. This in most cases is occasioned by the previous fits of indigestion, which terminate in the permanent disease. The chief seat of the tenderness, as I have found from repeated dissection, is in the pylorus, which is often as red as if it were actively inflamed; and this inflammatory state often, on the one hand, spreads more or less to other parts of the stomach, and on the other, to the liver, as pointed out by a corresponding extension of the tenderness on pressure. I have already explained why this chronic inflammatory state is always in the pylorus in the first instance, the passage from the stomach to the first bowel, the duodenum, which, we have seen,

rather deserves the name of a second stomach than that of a bowel.*

I have just pointed out the only addition necessary to be made in the treatment of the first stage of debility of the brain and spinal marrow, when the supervening disease attacks the lungs. The fret of nerve has become established, and necessarily proves fatal, when the supply of the only organs which we have seen afford the nervous influence necessary to the maintenance of all our vital organs fails; in consequence of which the structure of that most inclined to disease gives way, the final ceasing of the functions of any one of which is necessarily fatal. In considering the treatment of the first stage of debility of the brain and spinal marrow, I have entered on that necessary for the removal of the cause which supports the disease; and in the last stage it is only necessary to employ the same treatment still more assiduously when disease of another vital organ has actually taken place, and the patient's life immediately depends on its speedy removal, for which we have seen that of the original disease is essential, the fatal effect under such circumstances being at no great distance, if the cause which has been preying on the powers of the brain and spinal marrow cannot be removed.

It is easy to perceive from what has been said, that the only plan of treatment which applies to such cases, is, the combination of the means which tend to remove the last supervening disease, which is always an acute disease, with that of the treatment of the original affection from which it has arisen, which, as we have seen, is, necessarily, of a chronic nature.

* See Sir Benjamin Brodie's experiments, above referred to.

One of the most important points in the last stage of the case before us is, to obtain such an affection of the mouth, from the minute mercurial dose, as I mention in speaking of the treatment of the second stage of distended liver, if this has not been sooner accomplished; and if it has, to promote its recurrence, and render it as constant as can be done without the least risk of any degree of salivation, which is always, I believe, injurious in such cases, where, as far as I have observed, there never is any disease of structure in the liver, nor even any tendency to it; for we have seen the tendency of the last supervening disease is always to relieve the original disease, from which the whole arises. I have almost uniformly found, at all periods of distended liver, an improvement in the symptoms on a tenderness of the gums supervening; but I have not found it desirable much to increase the minute dose with a view to bring it on; and, indeed, this seldom has the effect, for, as in those in whom it is difficult to produce this effect, the difficulty most frequently arises from the mercurial running off too rapidly by the excretories, and particularly by the skin; and increasing the dose tends only to increase this effect; and we can often produce complete salivation by the minute dose, when the ordinary doses have wholly failed to produce it.

When the fulness in the region of the liver is not very perceptible, by making the patient speak, while pressure is made on the region of the distended liver, we may always, as the recovery goes on, judge of the degree of the distention remaining, and thus ascertain at what rate the recovery goes on, after the distention is too trifling to enable us to judge without this assistance; and I have uniformly found that when the

distention of the liver is wholly relieved, the pressure produces no difference in the breathing or speaking on the two sides. This is the only test I have been able to discover which can tell us that the liver has returned to its natural position under the ribs; and the degree in which this takes place is always a correct measure of the rate of recovery.

It is hardly necessary to add, after what has been said, that the effects of this disease are very various. They may, after they have induced a permanent fret of nerves, terminate in a fatal disease of the head, chest, or abdomen, according to the tendencies of the particular constitution, the period of life, and the circumstances in which the individual happens to be placed; the principle of the treatment being then a combination of that of the original and supervening diseases; for the latter of which I must refer to the works on those diseases.

In all serious diseases, we should carefully determine, from an examination of the state of the digestive organs, and the history of the case, how far the irritations of these organs have had a share in producing the attack the patient labours under; because if this has been the case, and the disease of those organs, even although in a mitigated form, remains, the removal of the more prominent disease is impossible, unless that in which it has had its origin be detected and removed.

Thus I have found, in many both acute and chronic cases, an examination of the region of the three great digestive organs, the stomach, particularly the pyloric region of this organ, liver, and duodenum, of as much consequence as that of the pulse, and often more so. For many years I have never failed to have recourse

to it; for even where such affections have no concern in the cause of the disease, they often, as above stated, from the extensive sympathies of these organs, supervene in it, and always influence its course, and ought, if present, to influence the treatment.

In by far the majority of chronic cases in which my opinion has been requested, in consequence of their unusual obstinacy, I have found the distended state of the liver the cause of the obstinacy, and, on its being relieved, the disease has yielded to the usual means.

If there be any truth in the preceding observations, and they are equally founded in the general laws of our constitution and practical experience, how erroneous must that treatment be by which all cases of the same disease of the same organ are often treated in the same way, whether arising from a cause immediately influencing the organ itself, or one which has made its first impression on another part of the system; without correcting the effects of which it is impossible to remove the more prominent disease: for a disease will, *à fortiori*, be supported by the continuance of the cause which had power to produce it. The correctness of this observation is strikingly illustrated by that disease which, on account of its eminence and frequency, I have chosen as an example of the last supervening disease; often even to the degree, if the structure of the lungs be still entire, and time remains for the effects of the proper treatment, I may say, of almost certain safety, instead of no less certain death. This last supervening affection characterises the last stage of the disease I have called distended liver, to which we have seen so many in these kingdoms annually fall a sacrifice, the

consequence of the physiological errors which have prevailed, and do still prevail, in our profession, as above explained.

There is a case of distended liver which I have found does not admit of a permanent cure; I mean where the debility of the nervous system is an original defect of the constitution; that is, has been born with the patient. In such constitutions, as may be inferred from what has been said of the nature of distended liver, the reader may be led to infer that there are no means of permanent cure, because, from the original defect, as soon as the means of cure are laid aside, the tendency to the disease necessarily returns.

The only means with which I am acquainted, by which, in such a case, a tolerable share of permanent health may be obtained, is, by never wholly laying aside the mercurial treatment; but, as very little of this treatment is required for preserving such a share of permanent health, after the distention of the liver has once been wholly removed, it little interferes with his general comfort, and may be obtained by means which, if necessary, may be continued for life without risk.

The plan I have pursued for this purpose has been to give the compound calomel pill, which is the mildest of all effectual preparations of calomel, the dose being generally five grains of the mass, which contains one grain of calomel, and to carry it off by a mild aperient in the morning, once or twice in the week, as the constitution of the patient requires, to prevent distention of the liver: for which purpose, its region must from time to time be examined, and when any distention of this organ is perceived, recourse must be had to

the minute dose every eight hours, till all fulness of the side disappears, by which, if had recourse to as soon as any distention of the liver can be perceived, it is generally soon removed. By such means, I have found that those whose nervous system is originally debilitated may generally be preserved in such a state of health as, with the necessary attention to rules of diet, and regularity of bowels, hardly deserves the name of disease; and I have never seen any bad effect from such a course of medicine, however long continued. The occasional dose never does harm; and if the above-mentioned pill, the popular name for which is Plummer's pill, is not sufficiently active, a grain of calomel, made into a pill with extract of liquorice, may be substituted for it. In most cases, combined with such an occasional dose, the minute dose seldom fails, after a certain continuance, to remove the distention of the liver, even in such cases; and the use of this dose may be laid aside till some degree of the distention again recurs.

By relieving the fret of nerve, by preventing the continuance of its immediate cause, the brain and spinal marrow are allowed to recover their powers, as far as the original debility of the constitution admits of it; and thus, from several such cases which have been under my care, I believe both life and a comfortable state of health may be preserved till an advanced age, even in such habits; the minute dose always acting on the liver as a tonic, and consequently, when the weakened state of this organ is the cause of the general debility, in a similar way on the whole system.

In all cases it will appear, from what has been said of the extensive sympathies of the liver, that care

should be taken to support the due action of the skin and other secreting organs; in short, as much as possible to preserve a state of general health, which is essential in the treatment of an organ which so greatly influences and is influenced by that of almost all others.

The reader will perceive, from all that has been said of the treatment of distended liver, that its success consists in effecting two objects: the first in enabling the liver so to discharge its contents that it may return to its healthy degree of distention; the last, so to strengthen its ducts and vessels that the morbid distention shall not recur. The last of these we found the most difficult, because all our powerful tonics tend to obstruct the liver, and consequently to produce the state we are endeavouring to remove; nor do I know any other tonic than the minute dose of mercury, given in the way and dose above pointed out, that can at all be depended on in this part of the treatment. The reader has seen the principle on which minute doses of almost all our more powerful medicines act more or less as tonics.

Section IV.

On a certain State of Indigestion, and of habitual Asthma.

What follows tends to illustrate several of the most important observations made in the preceding parts of this volume, and may be regarded as a proper postscript to all that has been said in the present chapter.

The diseases which form the title of this division,

arising apparently from a general and obstinate defective action of the secreting surfaces, depend on a weakened power of the central organs of the vital system ; in which I have found voltaic electricity the only effectual means of relief.

The first is a state of general debility uncharacterised by any particular symptom, generally the effect of the long-continued irritations of indigestion, which remains in certain constitutions after the permanent distension of the liver, and consequently the fret of nerve, have been removed ; and occasionally arising from some other causes.

Of the latter, which, as far as I know, had not been distinguished as an original disease, the reader will find a particular account in a paper I presented to the Royal Society, and which is published in the Philosophical Transactions for 1817, in which is given the result of the treatment of about a hundred cases of what I have called habitual asthma.

Most of these cases were treated, in the course of several years, in a public establishment, the County of Worcester Hospital (where the disease among the sedentary china manufacturers is of very frequent occurrence), and consequently in the presence of many observers. Some had been obliged to give up their employment in consequence of this disease, for no other means that were tried gave any effectual relief; and I do not recollect one instance in which they were not enabled to return to it by the use of voltaic electricity.

The disease consists merely in a constant state of oppressed breathing, which unfits the patient for all the active duties of life more or less, in general, but not necessarily, accompanied by cough.

The reader will perceive, from all that is said respecting the effects of voltaic electricity, which is now, I have already had occasion to observe, since the account of the experiments publicly repeated both in Landon and Paris, the former in 1822, an account of which will be found in the Philosophical Transactions for that year, the latter, on a far more extensive scale, in 1823, an account of which will be found in a publication referred to in the preface — I say, since these public repetitions of the experiments on which the inference is founded, the voltaic electricity is, I believe, generally admitted to be the power, which operates in the nervous influence, properly so called. In the third part of the fourth edition of my Inquiry into the Laws of the Vital Functions the reader will find the principles which should direct the employment of this agent in the cure of disease. The great outline may be comprehended in one sentence. The objects of its employment are for the time to supply the want of nervous influence, and thus to excite the vital organs to a better action: the chief precautions to be observed being, to take care that all inflammatory tendency be corrected before its use, and that it shall not excite any such tendency. The reader has seen Mr. Earle's report of its effects in restoring the due functions of the stomach and lungs in disease of the spinal marrow.

It is of course impossible for us to apply this power as nature herself applies it. We can neither confine it correctly to the proper parts, nor correctly apply it in the due degree. With due precaution, however, I cannot help hoping that in those diseases in which

the sensorial functions are entire, and the vessels healthy, and merely the functions of assimilation and secretion, which immediately depend on the nervous power, are in fault, voltaic electricity, when the states of the system necessary to secure its beneficial operation are generally understood, will in many instances prove an effectual means of relief in cases where we have few or no others.

As soon as this view of the subject presented itself, I was led to inquire, what diseases depend on a failure of nervous power. The effect on the stomach and lungs of removing part of the eighth pair of nerves answered the question respecting two of the most important diseases of this class. The reader has seen that withdrawing a considerable part of the nervous power from the stomach and lungs deranges the digestive powers, and produces great difficulty of breathing.

When the effect of artificially depriving the lungs of a considerable part of their nervous power is carefully attended to, it will be found in all respects similar to the disease I have here termed habitual asthma: in which the lungs are more or less clogged with phlegm, and the breathing is constantly oppressed, better and worse at different times, but never free, and these symptoms often continue to increase, in defiance of every means we can employ, till the patient is permanently unfitted for all the active duties of life; yet the failure of nervous influence may not have been sufficient to produce distended liver, the affection of the lungs coming on before it arrived at the degree necessary to produce this effect.

The animal, in the experiments referred to, is not affected with the croaking noise and violent agitation which generally characterise fits of spasmodic asthma.

This state we cannot induce artificially, except by means which lessen the aperture of the windpipe. It is the state of breathing observed in habitual asthma under which it labours; that is, a uniformly-oppressed breathing without stertor. The stertorous breathing in sanguiferous apoplexy seems always to arise from a contraction of the passage of the air into the windpipe, and evidently arises from the lessened power of the nervous influence, because I found the application of voltaic electricity immediately relieve it, the stertorous breathing returning on discontinuing the electric power.

The reader will find, from the facts stated in the fourth edition of my Inquiry into the Laws of the Vital Functions, that both the oppressed breathing and the collection of phlegm occasioned by the division and separation of the divided ends of the eighth pair of nerves may be prevented by causing voltaic electricity to pass through the lungs; and with respect to the stomach, that, after the capability of its function has been wholly destroyed, by depriving it of part of its nervous power, it may be perfectly restored, for the time, by the same influence.* That voltaic electricity may be employed with safety in the human body we know, from numberless instances in which it has been applied to it in various ways.

Such are the circumstances which led me to expect relief from it in indigestion and habitual asthma. The first trials were made above five-and-twenty years ago, as appears from the paper above referred to.

* The result of the trials of that form of electricity with which we have been most familiar, which is obtained by the common electrical machine, were, that its effects in disease are both less considerable and more transitory

The results in many instances were such as to exceed my expectations, and to have rendered the employment of the remedy pretty general, although the precautions necessary to render it most successful are, I believe, very little attended to. What these are I have explained more particularly in the seventh edition of this Treatise. For the account of my mode of application, and the means of protection from its unfavourable effects, I also beg leave to refer the reader to that Treatise.

In it, I have in other respects, as well as the employment of voltaic electricity, applied the results of the inquiry just referred to, to explain the nature and improve the treatment of indigestion and its consequences; and have been gratified by reports from practitioners in various parts of the kingdom confirming the advantages derived from the plans of treatment thus suggested; which, with the circumstance of the Treatise having undergone seven editions, encourages me to hope that my labours on this part of the subject have not been in vain.

It is reasonable to suppose, that its having been ascertained that a power which we are at all times capable of commanding, and that to any extent that can be required, having been ascertained to be capable of all the functions of the leading power of the vital system, must, if judiciously employed, often be of eminent service in the practical department of our profession; and such has been the result, although its good effects have been greatly counteracted by little or no attention having generally been paid to the precautions necessary to insure its most beneficial effects.

There is one of its effects the extent of which in

some instances has been very unexpected. It is evident that it may assist the organ to which it is applied in three ways, either by simply supplying the nervous influence where it is defective, in which case its effects are necessarily temporary, an instance of which the reader has seen in its employment in apoplexy; or by exciting the brain and spinal marrow to better action, as far as relates to the diseased part, which better action remains after being once excited; or lastly, by restoring to the ganglionic nerves of the part more vigour in conveying their influence to the part in question. Now I have never, with the exception just mentioned, seen its effects merely temporary, although they are much more so in some cases than in others; therefore its action must always be more or less by one of the last two means; but in some cases so small a power has sometimes produced so great an effect, that it can only be explained by supposing that its operation was wholly in one of these ways.

The following is the most remarkable case of this kind which has occurred to me. A lady of about thirty years of age applied to me for the removal of permanently oppressed breathing. She had never, even when she was a child, been able to run about with her companions, on account of shortness of breath, as she termed it, for which all remedies had been tried in vain, which, as she advanced in life, so increased, that she could not, when I saw her, even walk up hill without much suffering. She had no cough. I advised no medicine for her, but directed the moderate use of voltaic electricity, which was applied in my presence. In a few minutes she said she breathed with more ease than she remembered ever to have

done; but the most unlooked-for part of the result was, that she never required a second application of the remedy, her breath remaining as free as in the most perfect health, so that she could not only walk, but run up hill, with as much ease as other people; and, as far as I know, the effect was permanent, as I never heard anything more of her, which I certainly should have done had the difficulty of breathing returned.

I have seen some similar instances, in which a few applications of voltaic electricity produced permanent relief in the same species of asthma *, but no other so striking, both from the suddenness of the cure, and because the disease appeared to have been born with the patient.

* Voltaic electricity has little, if any, effect in relieving spasmodic asthma, unless it is complicated with habitual asthma, as I have defined it in the publications referred to, which sometimes happens in protracted cases.

APPENDIX,

CONSISTING OF

EXTRACTS

FROM

SOME OF MY PAPERS

WHICH THE ROYAL SOCIETY OF LONDON DID ME THE HONOUR TO PUBLISH IN THE

PHILOSOPHICAL TRANSACTIONS,

BETWEEN THE BEGINNING OF THE YEAR 1815 AND THE END OF 1836;

ILLUSTRATING

THE MORE IMPORTANT POSITIONS ON WHICH THE FOREGOING WORK IS FOUNDED.

APPENDIX, N° I.

Extract from a Paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1836.

The powers of the nervous system, properly so called, which cooperate with the muscular fibre in all the more complicated functions, next demand our attention; and it will appear that there is no other branch of physiology in which the generally received opinions have been, and indeed still are, so much at variance with simple matter of fact.

That what in common language is called the nervous system embraces two distinct sets of organs is evident; because not only do the functions of the sensorial and nervous organs, properly so called, essentially differ in their nature, but, as we shall find, their localities also are different. Now it has generally been taught that the nervous functions, properly so called, only administer to those of the sensorial power; that they are limited to the conveyance of impressions to and from the sensorial organs, and to the excitement of the muscles of voluntary motion.*

I shall in the first place inquire into the nature of

* See in the Report of the British Association for the Advancement of Science for 1833 a paper by Dr. Henry of Manchester; and a Dissertation on the state of Medical Science from the termination of the 18th century to the present time by Dr. Allison, Professor of the Institutes of Medicine in the University of Edinburgh, in the Cyclopædia of Practical Medicine, published in 1834.

the functions of the nervous system, properly so called, and then endeavour to ascertain to what parts of that system the powers on which those functions depend belong.

The mere structure of the parts might have led physiologists to suspect that the organs of this system possess other powers than those just enumerated. We find two distinct classes of nerves, to one of which the functions subservient to the sensorial powers evidently belong, and it has never been proved that the other at all partake of these functions. Besides, it had appeared from experiments relating to this second class of nerves, although their results were differently reported by different writers, that they must possess functions of a wholly different nature.

Such were the circumstances which called my attention to this, as it were superadded class of nerves; and I think it will appear from the facts I am about to adduce, both what are their functions, which we shall find much more complicated than those of the former class, and why the results of the experiments just referred to have been so differently reported.

The peculiarity of structure relating to these nerves is, that, while all the former class proceed, either from the brain or spinal marrow, directly to the parts they influence or which influence them; they either enter or send branches which enter a chain of protuberances called ganglions, from which nerves are sent to the parts influenced by them. Hence they are termed ganglionic nerves, a term, however, which has not been employed in a very strict sense; because, besides the ganglions just mentioned, which receive nerves from different parts of the brain and spinal marrow, there are other protuberances also termed

ganglions, which are formed on particular nerves, but which appear to have no relation to any nervous filaments but those of the particular nerve to which they belong. It is therefore necessary that I should define the sense in which I use the terms ganglion and ganglionic nerve. By ganglion, I mean a nervous protuberance which receives nerves from different sources; and by ganglionic nerve, a nerve which either enters or sends branches to such ganglions, or proceeds from them, whether it have or have not any such protuberance belonging to itself. It may be stated, however, that there is reason to believe that all nerves, having such protuberances, contribute towards forming the ganglions, in the sense in which I use the term.*

One of the most evident peculiarities of the ganglionic nerves, in the sense in which I use the term, is, that while the cerebral and spinal nerves supply the sensitive organs and the muscles of voluntary motion, the ganglionic nerves supply the muscles of involuntary motion and the other vital organs.

Haller, finding that the heart cannot be influenced through its nerves in the same way as a muscle of voluntary motion, was led to the conclusion that the former cannot be directly influenced through the nerves. But M. Le Gallois has shown that he was deceived in this inference, the heart being immediately subject to the influence of the spinal marrow; and the latter author further inferred from his experiments that the spinal marrow is not only capable

* See my paper on the Functions of the Nervous System in the Philosophical Transactions for 1829, which was republished in my treatise On the Nature of Sleep and Death.

of directly influencing the heart through its nerves, but that, through the same channel, it bestows on both the heart and blood-vessels all their powers; an inference refuted both by experiments already referred to, and others, an account of which appeared in the Philosophical Transactions for 1815, and has since been republished in my Inquiry into the Laws of the Vital Functions; and some of which were, at the request of the Royal Society, repeated, with the same results I had obtained, by Mr. Clift, Mr. Clift's confirmation of them being published in the same volume of the Transactions.

The circumstance of the brain and spinal marrow only, as we shall find, influencing the heart under peculiar circumstances is probably the cause of the fact, ascertained by Haller, that it cannot be excited through its nerves in the same way as a muscle of voluntary motion, an observation which applies to all muscles of involuntary motion, a want of attention to which has misled some physiologists.*

From the whole of the experiments which have been referred to, it appears, on the one hand, that neither the brain nor spinal marrow bestows any power on the heart or vessels; but, on the other, that each of the former organs is equally capable of directly influencing both (the vessels even to their utmost extremities), and that, not only by exciting their powers, but also by impairing and even wholly destroying them, according to the nature and power of the agent operating on the brain or spinal marrow; although, in their usual functions, the heart and vessels, like the

* See my reply to MM. Breschet and Milne-Edwards in the Philosophical Transactions for 1833, entitled Some Observations relating to the Function of Digestion.

other muscles of involuntary motion, obey neither of these organs, but agents peculiar to themselves.*

Thus it appeared that the ganglionic, like the cerebral and spinal nerves of motion, may administer towards the contraction of the muscular fibre, unless, what I conceive to be more probably the case, although not yet ascertained, branches of the latter nerves are bound up in the same sheath with the ganglionic nerves †, as we shall find there is reason to believe is the case with respect to the nerves of sensation. Physiology has been much indebted to the experiments of Sir Charles Bell, M. Majendie, and Mr. Mayo, from which it appears that the nerves of motion and those of sensation, although often bound up in the same sheath, are distinct nerves, having different origins.

What are the functions which are peculiar to the ganglionic nerves, in the sense in which I use that term?

This question is answered respecting one of the most important of the vital functions, the process of secretion, in papers published in the Philosophical Transactions for 1815 and 1822, and republished in the last edition of my Inquiry into the Laws of the Vital Functions.

It appears from the experiments detailed in those papers, that when part of the eighth pair of nerves in their passage along the neck is removed, or these

* See two of my papers published in the Philosophical Transactions for 1815, and republished in my Inquiry into the Laws of the Vital Functions.

† It now appears, from what is said in subsequent volumes of the Philosophical Transactions, and in the fourth edition of my Treatise on the Laws of the Vital Functions, that this is not the case.

nerves are divided, and one end of either portion is raised from its place, the secretion of a gastric juice soon begins to fail in its properties; and if the animal survives for a certain time, the contents of the stomach are found not only undigested, but quite dry, proving that there had been no secretion from it whatever for some time.

From these experiments we also learn how it has happened that such various accounts of the effects in the stomach of dividing the eighth pair of nerves is given by different experimentalists; because it was found that digestion was more or less completely interrupted in proportion as the divided ends of the nerves were kept at a considerable distance from each other. Even when the distance was a quarter of an inch, provided the divided ends were no otherwise displaced than in consequence of the retraction of the nerve on its division, digestion, although more or less deranged, was not interrupted, a subject to which I shall have occasion to recur. Now as this was a point which never particularly demanded attention, accident must always have more or less influenced the result.

But secretion is not the only vital function that is influenced by the division and separation of the divided ends of the eighth pair of nerves in the neck. It appears from experiments detailed in my paper, published in the Philosophical Transactions for 1827, and republished in my treatise On the Nature of Sleep and Death, that, under such circumstances, all the assimilating functions are so deranged, that in many parts of the lungs, in the space of fifteen or twenty hours, not a vestige of their healthy structure remains.

Such it appears are the effects on the stomach and lungs of depriving them of a considerable portion of

the influence of the brain. They are organs well adapted for such observations. In the stomach we have certain means of judging of any considerable deviation in the process of secretion; and from the peculiar structure of the lungs, they are well adapted for observations on changes of structure. That the effects are proportioned to the degree in which the influence of the brain is withdrawn, appears from comparing those of dividing and separating the divided ends of one or both nerves.

It is not however to the brain alone that similar observations apply, for it was found that depriving the stomach and lungs of the influence of the spinal marrow is attended with the same effects. When the lumbar portion of this organ was destroyed, the functions of the stomach and lungs and the structure of the latter were as much impaired as by the division and separation of the divided ends of one of the eighth pair of nerves; and when the lower half of the spinal marrow was destroyed, as much, as by the division and separation of the divided ends of both those nerves.*

It thus appears that the powers on which the secreting and assimilating functions depend reside in the brain and spinal marrow, and equally in these organs; nor does either of them act through the other in influencing the vital organs, as the brain is found to do through the spinal marrow in influencing many of the muscles of voluntary motion, the heart and vessels in every part being equally influenced by agents acting either on the brain or spinal marrow, when the

* See my Inquiry into the Laws of the Vital Functions, Part II.

other has been removed, as while both with all their connections remain.*

The question which next presents itself is, how far are they assisted in these offices by the nerves, ganglions, and plexuses? From which many have supposed that the nervous influence bestowed on the vital organs is wholly derived.

In a paper published in the Philosophical Transactions for 1833, and republished in my treatise On the Nature of Sleep and Death, I have entered into this question at great length, where such observations and experiments will be found, as far as I am capable of judging, as render the following inferences unavoidable: —That the ganglions, plexuses, and their nerves, in no degree contribute to the formation of the nervous influence; the spinal and cerebral nerves being merely the means of conveying the influence of the parts of the brain and spinal marrow from which they proceed, and of conveying to these organs the influence of impressions made on their extremities; while the ganglions and plexuses with their nerves are only the means of combining the influence of all parts of the brain and spinal marrow, through all parts of which the organs of the nervous power, properly so called, are distributed; the nerves proceeding from the ganglions and plexuses being the means of conveying this combined influence to the muscles of involuntary motion and the other vital organs.

The question here arises, for what purpose is the influence of every part of the brain and spinal marrow thus combined to be bestowed on these organs?

This question is answered by the experiments just referred to, which prove that the influence of every

* See my Inquiry into the Laws of the Vital Functions, Part II.

part of the brain and spinal marrow is necessary to the due performance of the functions of secretion and assimilation; and by other facts to which I shall have occasion to refer, which prove the necessity of the muscles of involuntary motion being under the control of the same power, on which these functions depend.

All of them, as we have just seen, fail when any considerable part of the influence either of the brain or spinal marrow is withdrawn, the failure of function being proportioned to the degree in which the influence of either is withdrawn, proving that the influence of every part of them is essential to the due performance of those functions.*

Important and extensive as these functions are, there is still another, hardly less so, dependent on the powers of the nervous system, properly so called. Sir Benjamin Brodie† proved by direct experiment many years ago, that animal temperature is under the influence of the nervous system, and various observations evince that a debilitated state of the brain is accompanied with a diminished temperature.

I made many experiments on this subject detailed in my Inquiry into the Laws of the Vital Functions, from which it appears that in this, as in all the other vital functions, the spinal marrow shares with the brain. If the power of either organ be impaired, the temperature sinks in precisely the same proportion as the secretions are deranged. A particular organ may be deranged by preventing its due supply of nervous

* See my papers which appeared in the Philosophical Transactions for 1815 and 1827, and my Inquiry into the Laws of the Vital Functions, Part II.

† See the Philosophical Transactions for 1812 and 1814.

influence, and there may be no general diminution of temperature. The due nervous influence is prevented reaching the particular organ, but there is no diminution of the power of the brain or spinal marrow. When, on the other hand, the power of either of these organs is impaired, there is an immediate diminution of temperature.

When the lower half of the spinal marrow was destroyed, the animal shivered, and would probably soon have died of cold if it had not been kept in a high temperature; and even when the lumbar portion alone was destroyed, a considerable but less diminution of temperature ensued.*

Thus it appears, from the whole of the facts which have been referred to, that on an influence derived from the brain and spinal marrow, and not from any part, but from the whole of these organs, the secreting and more immediately assimilating functions and the maintenance of animal temperature depend. This influence, therefore, performs a still more important part in the vital than in the sensitive functions. In the latter we find it acting only a subordinate part; while in the former it must be regarded as the great agent, to which all others employed are subservient.

Has the nervous influence any immediate dependence on any of the other powers of the animal frame?

The muscular, we have seen, has no immediate dependence on the nervous power, the only power on which its immediate dependence can be supposed. In like manner the sensorial is the only power on which any immediate dependence of the nervous power can be supposed.

* See my Inquiry into the Laws of the Vital Functions, Part II.

I made an extensive set of experiments, detailed in my Inquiry into the Laws of the Vital Functions, to which I shall soon have occasion to refer more particularly, from which it appears that all the functions of the nervous power, properly so called, survive the removal of the sensorial power, with the exception, of course, of those in which that power is associated with it. After the removal of the sensorial power the nervous influence is still capable of all its other functions. It is still capable of exciting the muscles both of voluntary and involuntary motion, of, for a short space of time, forming the secreting fluids, performing the various functions of assimilation, so far as to preserve the structure of parts where it would otherwise have been impaired, and, to a certain degree, of maintaining animal temperature. The nervous, like the muscular power, therefore, is an independent power, having its seat in its own organs, and having no other dependence on the other powers of the living animal than for the due structure of those organs.

Such are the powers of the nervous and muscular systems of the more perfect animals, and the seat and functions of these powers.

They possess, however, two other sources of power, for the sensorial power and the powers of the living blood have no immediate dependence on either of the former powers, or on each other.

That the only dependence of the sensorial power is for the maintenance of its organs is evident on the most cursory view of the animal economy. The nature of the functions of that power alone evinces that the living animal possesses no others from which it can be derived; and that the powers of living blood

have no direct dependence on its other powers is proved by the fact, that the blood retains its vital properties after it is separated from the body.*

With respect to the locality of the latter powers, the powers of the living blood, it appears from the fact just stated, existing in itself, must be coextensive with the functions of secretion and assimilation. At first view it would appear that the functions of the sensorial power, like those of the living blood, pervade every part of the system ; the power of sensation seems to pervade the whole frame. On observing the phenomena with more care, however, we find the seat of the sensorial power confined to a small space, when we compare it with that of the nervous power, properly so called, the organs of which we have seen pervade the whole of the brain and spinal marrow.

The nerves of sensation in which are included, of course, the nerves of the external senses, and the immediate organs of the sensorial powers are not parts of the same organ, but distinct parts, having different localities, and performing functions of a wholly different nature ; that is, the sensorium does not pervade the whole system, but belongs to particular parts. To what parts has never been, correctly ascertained, but we know that in man they are confined to certain parts of the brain, with little if any participation by the spinal marrow ; although in some of the inferior animals the spinal marrow largely partakes of them, — a proof that the sensorium is not, as some have supposed, confined to a physical point, but is of a considerable extent.

* See Mr. Hunter's experiments on the Blood, and the experiments detailed in the last chapter of the second part of my Inquiry into the Laws of the Vital Functions.

Our sensations are referred to certain parts of the body by experience alone. Hence the well-known facts that infants are not aware of the parts of the body in which the cause of any sensation originates; and when a limb has been lost, at whatever part the separation is made, we continue to refer to the lost part sensations excited by causes affecting the nerves of the stump.

The function of the nerves of sensation has relation to the sensorial organs alone. The influence they convey is the means by which the sensorium is impressed by distant parts, and such is their only function.

The more perfect animals then possess four distinct powers, having no direct dependence on each other, but each we shall find indirectly dependent on the other three, namely, for the maintenance of its organs.

I am now to inquire how far we can advance in determining the nature of these powers, how far they are peculiar to the living animal, or the same which operate in other parts of nature.

We are in the habit of regarding life as a power of peculiar mystery, but do we find any other principle of action less mysterious? It is not the principle, but its properties, which are the objects of our senses. A knowledge of the former is not merely beyond the limits, but the nature of our minds. Do we know more of the principle of electricity or gravitation than of life, or is there more uncertainty, for example, in noting the property of resistance to fermentation and congelation than properties of any other de-

scription? It is not that the nature of life is more obscure than that of any other principle of action, all are equally so, but that its phenomena, being more varied and bearing less analogy to those of other principles than these bear to each other, are less familiar objects of contemplation.

The subject thus appears invested with an obscurity which is not peculiar to it, and the perplexity has been increased by vain attempts to remove it; attempts on principles having no relation to the laws by which the phenomena of life are regulated. What possible relation can the laws of mechanics, or any other principle which operates in the inanimate world, bear to the phenomena of life, properly so called? It is as much a distinct principle as any of those which operate in that world, and the same method which leads to a knowledge of other sciences must guide us here. There are no means but a study of its phenomena by which we can attain a knowledge of life, that is, of its properties, the only knowledge we can attain of any principle of action. But if our object be to attain a correct knowledge of it, we must first determine with accuracy what are the phenomena of life; for, in the complicated functions of the living animal, it requires not a little patience, labour, and circumspection, to distinguish what part depends on vital powers properly so called; and what, on a modification of the powers of inanimate nature. Even the most cursory view must convince us that many of the functions of the living animal partake of the latter powers.

Respiration is performed, that is, the air is drawn into and expelled from the lungs, by means which act on the same principle as the bellows. The blood in

the circulation moves on the same principle as the water in a set of water-pipes. It obeys a propelling force, and is subjected to the same laws of gravitation. The motion of our limbs is effected by the same mechanical laws, by which bodies are put in motion in the external world. Here, as in inanimate nature, velocity can only be obtained by the sacrifice of power. Similar observations apply to the various processes of secretion and assimilation. We can trace in these processes, the same chemical laws which obtain in the laboratory of the chemist; but there is at the same time in all the foregoing functions something more in operation, analogous to which we find nothing in inanimate nature.

The force indeed by which the air is drawn in and expelled in respiration operates on the same principle as in the bellows; but the powers by which the machinery is worked are the contractile power of the muscular fibre, and the power of the nerves by which it is excited. The motion of the blood depends on the same principle as that of the water in its pipes, but it is the contractility of the muscular fibre which supplies the moving power. The same observation applies to the motion of the various members of our body.

In like manner, in the processes which maintain the organs of all these functions, and effect the separation of those parts of them which have become useless, and therefore noxious, while we trace the same chemical laws which operate in other parts of nature, we can perceive that they are constantly modified by the powers peculiar to the living animal; for it is not only impossible by any chemical arrangement to produce the same results in inanimate nature, but

even by the principles which regulate its phenomena, to trace all the steps by which they are effected. We can neither, for example, imitate the process by which the temperature of living blood is raised above that of the surrounding medium, nor, on the principles of the chemistry of inanimate nature, trace all its steps. No position can be more erroneous than that the chemical processes of the living animal depend alone on the same laws with those of inanimate nature. The properties of life are as peculiarly its own as the properties of gravitation.

I am now to attempt to draw the line of distinction between the powers, which the living animal possesses in common with inanimate nature, and those peculiar to itself.

With respect to its mere mechanical powers to which I have just had occasion to refer, there can be but one opinion, that they are powers common to the living animal and inanimate nature; but with respect to the powers we have been more particularly considering, all of which appear at first view to be powers peculiar to the former, the question is not so easily answered. Until it is answered, however, it is evident that we cannot draw the line which correctly separates the phenomena of life from those which result from other principles of action, a line essential to an accurate view of the properties, that is, to a knowledge of that principle.

The question which I am here to consider, then, is, how far are the sensorial, nervous, and muscular powers, and the powers of living blood peculiar to the living animal, or possessed by it in common with inanimate nature?

It requires but little consideration to answer the question respecting the sensorial and muscular powers, and the powers peculiar to the living blood. Where do we find in inanimate nature a power which can be mistaken for any of them? But even the most cursory review of the functions, which, it appears from the experiments above referred to, are those of the nervous power properly so called, makes us pause. That the oxygen and carbon of the blood combine by the same agency as in the laboratory of the chemist, is a position too probable to be hastily dismissed; and if such be the case, to what other functions of the nervous influence will the same observation apply?

The following, it appears from experiments above referred to, comprehend the nervous functions properly so called.

1. The excitement of the muscles of voluntary motion in all their functions.

2. The excitement of the muscles of involuntary motion in some of their functions.

3. The maintenance of the processes on which animal temperature depends.

4. The formation of the various secreted fluids. And

5. The more immediate processes of assimilation by which the structure of our various organs is both effected and maintained. Of these functions, the excitement of the muscles alone is the only one which may be supposed to be the effects of either a chemical or mechanical agent.

In all the healthy functions of life, however, in which the muscular power is employed, the stimulus which excites it, if we except the mere power of dis-

tention, appears to be of the former description Even those stimulants which maintain the functions of the alimentary canal, which, remotely depending on the stimulus of the food, may at first view be supposed to be the effect of a mechanical agent, appear to be wholly of a chemical nature. The ingesta will not excite a secretion of gastric juice unless they possess chemical properties of a certain description, and the muscular coat of the stomach is not duly excited unless the food has been converted into a healthy chyme, the formation of which, it appears from direct experiments, depends on the healthy state of the influence supplied by the brain and spinal marrow.* In like manner, the healthy action of the intestines, as appears from a thousand observations, can only be maintained when their healthy stimulant has been duly prepared by the additional chemical processes which take place in the duodenum; which also depend on the influence supplied by the brain and spinal marrow. It is evident that all the other functions just enumerated are of a chemical nature. It thus appears that all the nervous functions are chemical processes, and consequently that there may be an expectation of finding an agent in inanimate nature capable of them.

It was found that in proportion as the nervous influence, properly so called, is withdrawn, all these processes fail. It is evident, therefore, that on this influence the changes observed depend. Whatever therefore that influence may be, all its functions in their general nature are identical with the effects of the

* Philosophical Transactions for 1815 and 1822; and Inquiry into the Laws of the Vital Functions, Part II.

chemical agent, whatever that agent may be, which operates in inanimate nature. This step therefore appeared to be gained. Further reasoning, however, was unnecessary, because it was not difficult to submit the question to the test of direct experiment.

I was thus led to consider what power of inanimate nature it was most probable might be successfully substituted for the nervous influence.

An important point had been ascertained. It had been found that of all the powers of inanimate nature, voltaic electricity is most capable of the excitement of the muscular fibre, that is, of one of the functions of the nervous influence. This indeed went but a short way towards establishing the identity of the two powers, so many other stimulants being capable of exciting that fibre. It is not to be overlooked, however, that feeble as this argument is towards proving the identity of the nervous influence and voltaic electricity, it is powerful respecting the general nature of that influence; because on the supposition of the nervous influence being a vital power, properly so called, we have here a vital power possessing a property in common with a thousand inanimate agents. Is there any unequivocal instance in which any of the properties of a vital principle, properly so called, is not essentially different from those of any of the principles of inanimate nature? On the whole, the property in question was sufficient to suggest the trial how far voltaic electricity is capable of the other functions of the nervous influence.

No hope of success of course could be entertained unless the artificial agent were employed under the same circumstances under which the nervous influ-

ence operates; that is, while the structure of the organs is entire, and their vital properties unimpaired.

Under such circumstances I substituted it for the nervous influence in the various functions of secretion and assimilation with success. It was admitted by those who witnessed the results, that these functions were as effectually performed by it as by that influence itself; and the experiments were afterwards publicly repeated both in London * and Paris †, in the latter on a great variety of animals, and in all instances with the same results. In the first of my papers published in the Philosophical Transactions for 1829, entitled Some Observations relating to the Function of Digestion, several circumstances are enumerated which it is necessary to keep in view in conducting such experiments.

Only one of the functions of the nervous influence now remained which had not been effected by voltaic electricity, the process by which animal temperature is maintained. For the purpose of determining how far it is capable of this function, it was judged the most satisfactory means to expose the living blood to its effects, both in its arterial and venous state. If voltaic electricity operate on the same principle as the nervous influence, it will raise the temperature of the former, but not of the latter, which has already under-

* The Journal of the Royal Institution of London for 1822. See also the London Medical and Physical Journal for May, 1820, vol. xliii. p. 385.

† De l'Influence du Système Nerveux sur la Digestion Stomachale; par MM. Breschet, D. M. P., Chef de Travaux Anatomiques de la Faculté de Médecine de Paris, &c.; H. Milne-Edwards, D.M.P.; et Vavasseur, D. M. P. (Mémoire lu à la Société Philomatique, la 2[e] Août, 1823.) Extrait des Archives Générales de Médecine, Août, 1823.

gone the operation of that influence. Such was found to be the case. The arterial blood immediately rose several degrees on coming into contact with the voltaic wires, but there was no increase of temperature in the venous blood, although, in both instances, the blood was subjected to them as it flowed from the vessels, it having appeared from previous experiments that the delay of even a few minutes, although no apparent change had taken place in the blood, and no elastic fluid had been disengaged from it, prevented any rise of temperature; so rapidly do some of the properties of living blood undergo a change after its removal from the vessels.*

Such being the facts, I could no longer doubt that the nervous influence and voltaic electricity are powers of a similar nature, and it appeared to me that this would be most convincingly illustrated, by causing the nervous influence to pass through other conductors than the nerves; because such a fact would, independently of all others, prove that it is not a vital power properly so called, it being acknowledged on all sides that no such power admits of separation from the texture to which it belongs in the living animal.

With this view I made many vain attempts, and hardly escaped the ridicule of my associates for expecting that the nervous influence could exist in any texture but that to which it belongs in the living animal.

In the third edition of my Inquiry into the Laws of the Vital Functions, the reader will find the circumstances detailed which led to the successful ex-

* See the second part of my Inquiry into the Laws of the Vital Functions; Experiments 80, 81, 82, 83, 84, and 85.

periment, the result of which was publicly confirmed both in London and Paris; and those who in the first instance ridiculed my expectations, joined me in stating that such is the fact.

The cause of failure in my first experiments on this subject, was the circumstance of having made a wrong choice of the nerve on which I operated, which was a nerve of voluntary motion.

It will appear on reflection that this was a wrong choice. Before we can expect that the nervous influence can be made to pass through any other conductor than that to which it belongs in the animal body, there must exist a powerful cause soliciting it to some particular point. In a muscle of voluntary motion there can be no such cause. The nervous influence is not attracted to the muscle, it is sent to it by an act of the sensorium, carried into effect by the powers of the nervous organs, which are subjected to its influence; those organs which, on the one hand, prepare that influence, and those which, on the other, convey it when duly prepared.* The muscle is altogether passive till the influence is applied to it. But the case is wholly different with respect to many of the organs which contribute to the functions of the ganglionic system. We know from direct observation that in many of them, there is a cause continually operating, which solicits the nervous influence to them.

In these organs the living blood and nervous influence cooperate in the functions of secretion and assimilation; and it is an acknowledged fact, that

* See the second of my papers in the Philosophical Transactions for 1829.

when a determination of blood to secreting organs takes place, there is in the same proportion an increase of their secreted fluids, a result which cannot arrive without a corresponding supply of nervous influence. Thus we know, as indeed we had reason to expect, that the presence of the living blood in the secreting organs solicits a proportionable supply of that influence; and thus it was, that whereas, while I operated on the nerves of voluntary motion, my attempts were wholly fruitless, the very first attempt with the ganglionic nerves was crowned with success; nor since the public repetition of the experiments in London and Paris, has the fact been questioned.

If the facts I have stated be correct, we can have little doubt that the nervous influence is of a nature similar to the inanimate agent which was substituted for it; for to say nothing of the circumstance of the nervous influence being capable of existing in a texture different from that to which it belongs in the living animal, we cannot suppose that there are two distinct powers, the one of which is capable of all the effects of the other; or I would rather say, that such a supposition amounts to a contradiction in terms, because as it is acknowledged that we know nothing of any principle of action but by its properties, it necessarily follows, that by these alone it can be distinguished.

APPENDIX, N° II.

Extract from a Paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1833.

We are now to consider the effects of sleep on those organs which have no share in its production.

One of the most important circumstances relating to the state of the sensitive system in sleep is, that the insensibility is never so complete as, under all circumstances, to prevent its excitement. On this alone it depends, we shall find, that it has no fatal tendency. The degree of sensibility which remains in sleep is the distinguishing mark between it and the torpor of disease. That sleep alone is healthy from which we are easily roused. If our fatigue has been such as to render it more profound, it partakes of disease ; that is, as will appear more clearly from what I shall have occasion to say of the different species of apoplexy, the vital system partakes of the debility, or some cause is operating which prevents the restoration of the sensitive system.

Distinct as the vital and sensitive systems are, we know that neither can long survive the other. In a paper which appeared in the Philosophical Transactions for 1829, I stated or referred to the facts which prove that in all modes of death, except the most sudden, arising from causes which so impress the nervous system as instantly to destroy all the functions, those of the sensitive system are the first which cease. The animal only dies when his means

of enjoyment and intercourse with the world which surrounds him, no longer exist. This consequence is constant and never long delayed. It is necessary therefore to a clear view of the state of the functions of the animal body in sleep, to determine the bonds of union between the sensitive and vital systems, at first view so distinct, which render their existence, except for a very limited time, inseparable.

That the sensitive cannot exist independently of the vital system, is evident, on the slightest consideration; but the dependence of the latter on the former is much less so. The facts stated in the paper just referred to, prove that in the more perfect animals, the function of respiration, being the only vital function which requires the cooperation of the sensitive system, is here the bond of union. It appears from those facts that the muscles of respiration are, in the strictest sense, muscles of voluntary motion, the excitement of which consequently depends on the powers of that system. When the power of sensation wholly ceases, we cease to breathe.

So confused have been the ideas of physiologists on this part of the subject, that to account for the continued action of the muscles of respiration and their intimate connection with the vital system, they have supposed a third class of muscles partaking of the nature of both the others, those of voluntary and involuntary motion, to which it has been alleged the muscles of respiration belong. If this be the case, these muscles must change their nature every instant, because they are the same muscles which are employed in a thousand other acts universally acknowledged to be mere acts of volition; and, on the

other hand, when powerful causes impede the breathing, all the muscles of the trunk are employed in this function. Besides, the facts which have been laid before the Society prove not only that there is no such class of muscles as that here supposed, but that the laws of excitability are the same in all muscles, the difference between the muscles of voluntary and involuntary motion depending wholly on the nature of their functions and the circumstances in which they are placed. The nervous influence, although equally capable of influencing both, is supplied to them in different ways and for different purposes, the usual functions of the muscles of voluntary wholly, of involuntary motion in no degree, depending on that system. The action of the muscles of respiration continues during sleep, because the exhaustion of the sensitive system is not complete, and the cause which influences this system in their excitement, continues in our sleeping as well as waking hours ; and the same is true of all other muscles of voluntary motion, as far as the causes which induce us to excite them are applied. In the soundest sleep we move our limbs if their posture be rendered uneasy. Are we not obliged to guard against these causes in sleep, else the motions they would produce would quickly rouse us ? Those of respiration are too gentle to produce this effect.

The only change which takes place in the action of the muscles of respiration during sleep is, that in proportion as the sensibility is impaired they are excited less readily, and the act of respiration is thus rendered less frequent, a more powerful application of the cause being required ; the consequence of which is, that when they are excited, the air is drawn

in with greater force; hence, and from the relaxation which is apt to take place during sleep in the parts about the fauces, the cause of snoring.* Thus we generally observe that the snoring is the louder the slower the breathing, that is, the relaxation of the fauces being the same, the more profound the sleep. The loudest snoring I ever heard, so loud as to startle the attendants, was in the last ten minutes of the life of a person who died of a disease of the brain impairing the sensibility, and who only breathed three or four times during that space.

The other changes observed in the vital system in sleep are evidently the consequence of the diminished frequency of respiration. This necessarily produces a proportional diminution in the frequency of the pulse; the properties of the blood being less frequently renovated in the lungs, it less readily excites the heart and vessels, and the diminished force of circulation is as necessarily attended with a diminished formation of the secreted fluids. This state of the vital organs, in its turn influences the sensitive system, and thus the sleep is rendered more profound. While health continues, however, the vital powers are never sufficiently impaired to prevent the perfect restoration of those functions by which the animal is again fitted for intercourse with the external world.

The foregoing positions are well illustrated by the

* Such facts are adduced in the paper last referred to as I believe will be admitted to prove that respiration is at all times an act of volition, excited by the sensation caused by the want of fresh air in the lungs; and the more the sensibility is impaired, the want must be allowed to become the greater, in order to excite the effort which relieves it.

symptoms of apoplexy, in which a cause exists that prevents this restoration, and which consequently points out to us in a more striking manner the influence of the sensitive on the vital system. Here we find that in proportion as the sensibility fails, the respiration, and with it the pulse, continue to become slower; and when it has failed altogether, so that no cause of irritation can excite any sensation, the respiration ceases, and the loss of circulation soon follows. In this way the patient dies in sanguineous apoplexy, where the cause of derangement is a gradually increasing pressure on the brain, in consequence of which its sensibility is at length extinguished. Here there is no original disease of the vital organs. Could the sensibility be sufficiently maintained to preserve a due frequency of respiration, and nourishment from time to time be introduced into the stomach, life would go on as in sleep, till the increasing affection of the brain, extending from the sensitive to the vital parts of that organ, so deranged the assimilating processes as to destroy life in this way.

The accumulation of phlegm in the lungs in apoplexy arises from these processes being deranged by the failure of nervous influence. I have repeatedly, in apoplexy, removed this accumulation of phlegm, the breathing becoming as free as in health, by causing voltaic electricity to pass through the lungs in the direction of their nerves. This, it is evident, can have no direct tendency to remove the disease, although by its means life may often be prolonged, and thus more time afforded for the application of the means of cure, this accumulation of phlegm greatly impeding the due change of the blood in the lungs,

and thus conspiring, with the diminished frequency of respiration, to deprive it of its vital properties.*

A short comparison of the symptoms of apoplexy from compression, with that which is with great propriety termed nervous, will throw additional light on this part of the subject.

It is shown by experiments detailed in papers which appeared in the Philosophical Transactions for 1815, that although the power of the heart and vessels is independent of the brain and spinal marrow, causes operating on these organs are capable of influencing them, and that even to the total destruction of their power. When, therefore, the cause of apoplexy, instead of being a gradually increasing pressure of the brain, — which I have found by experiment, however powerful it may be, has no direct influence on the action of the heart†, — is of such a nature as, while it impairs the sensibility, also directly impairs the power of the heart and blood-vessels, we have a disease of a very different nature from apoplexy from mere compression. In the latter, if we can remove the cause of pressure and prevent its recurrence, we invariably cure the disease. There is no other cause of derangement. The vital functions are only impeded by the want of the due change of the blood in the lungs, in consequence of failure in the functions of respiration and assimilation. Death here is necessarily slow, because it always requires some time for the gradually increasing pressure either to destroy the sensibility, and consequently wholly stop

* Experimental Inquiry, third edition, Part III. On the Application of the Experiments to Explain the Nature and Improve the Treatment of Diseases, Chap. I.

† Ibid. Part II.

respiration, or so derange the assimilating processes, as in this way to prove fatal, for from some peculiarity in the cause, the effect of which more readily than usual spreads to the vital parts of the brain, death, in apoplexy from compression, sometimes appears rather to arise from this derangement than the loss of sensibility, the phlegm gradually accumulating in the lungs till it wholly prevents the necessary change of the blood effected in them.*

But when the cause which impairs the sensibility also through the ganglionic system immediately enfeebles the heart and blood-vessels, the course of the disease is very different. We have here a cause at once impairing the powers of circulation; and when it is excessive, death is often instantaneous. Such is the cause of death from blows on the head, which, when not sufficient to produce instant death, produce what is called concussion of the brain, in which a state analogous to syncope is combined with impaired sensibility. The circulation is doubly assailed by the direct diminution of the power of its organs, and a failure in the stimulating power of the blood, in consequence of its less perfect decarbonisation, and the former, being the more powerful cause, obscures the effects on the vital organs of the latter. The pulse, instead of being slow but regular, and of unimpaired strength, is feeble, irregular, and fluttering, and a general paleness of the surface indicates a degree of failure of circulation, far beyond what is observed in cases of mere compression.

* This accumulation of phlegm in the lungs has been found experimentally to be the uniform consequence of lessening the supply of nervous influence in the lungs. — My papers in the Philosophical Transactions for 1827 and 1828; and my Experimental Inquiry into the Laws of the Vital Functions, Part II.

All sudden and excessive affections of the brain may produce the same effects as the blow on the head. Thus, people have instantly expired from rage or excessive joy, and thus in the mobs of Lord George Gordon, some from the sudden effect on the brain through the nerves of the stomach expired on taking a draught of spirit of wine which they had mistaken for common gin.

But it is not necessary that the cause, as in these cases, should be either sudden or violent to produce this species of apoplexy. A long-continued recurrence of slighter causes weakening the powers of the brain, often, along with them, gradually impairs those of the heart and blood-vessels, in the same way that an infusion of tobacco, applied to the brain in the experiments above referred to, impaired their powers. These are the most common causes of nervous apoplexy; and in proportion as their operation has been slow, the course of the disease is less rapid.

Thus we see it supervene in those who have been long exposed to the irritations which attend the more serious and confirmed cases of indigestion or long continued causes of anxiety, particularly in gouty habits, in which there is often a great tendency to debility in the vital organs; and we readily perceive, from what has been said, why apoplexy from such causes is so generally fatal. The powers both of the nervous and circulating systems are undermined, and with them the secreting and other assimilating processes which depend on them. The powers which ought to respond to our remedies have failed. Our efforts therefore are for the most part equally unavailing in restoring either the sensibility or the powers of circulation, and both are necessary to recovery.

APPENDIX, N° III.

Extract from a paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1833.

In the last paper which I had the honour to present to the Society, and which appeared in the Philosophical Transactions for 1831, I endeavoured, by comparing the various facts relating to the circulation of the blood, and by such additional experiments as seemed to be required, to free the subject from the confusion in which it had been involved by the various and contradictory experiments and statements of writers, and to ascertain the source and nature of the powers on which the motion of the blood depends.

In the present paper I propose to consider in the same way another subject of equal importance, intimately connected with the preceding, and which has, by the same means, been involved in equal, and, from its more complicated nature, apparently greater perplexity, — namely, the relation which subsists between the nervous and muscular systems, and consequently, between the nervous system and organs of circulation; for I think it will be admitted, from the statement of facts made in the paper just referred to, that the power of the vessels, like that of the heart, is a muscular power, and that on the combined power of the heart and vessels the motion of the blood, in

the ordinary states of the circulation, wholly depends. Having considered this part of the subject, I shall endeavour to point out how far we can proceed in ascertaining the nature of the nervous influence, the means by which the relation between the nervous and muscular systems is maintained.

I need hardly observe that in experimenting on a subject so complicated as the living animal body, much practice as well as caution is necessary in order to guard against erroneous conclusions, and thus obtain for physiology the certainty which can alone entitle it to be regarded as a science. There is none of its branches which has not suffered from the inaccuracy of experimentalists, and, from the complicated nature of the subject, none which has suffered more in this way than that to which I am about to call the attention of the Society.

Throughout the long inquiry in which I have been engaged, I have always been more anxious to secure any ground I had gained, by a careful repetition of the experiments, than to proceed to further attempts; and I may be allowed to state, that although my experiments have been repeated by many of the first physiologists, both of this country and the continent, they have not in any instance been found inaccurate. The rules I have always followed, and which, if I may presume so far, I would recommend to all engaged in such inquiries, are to make the experiments in the presence of competent witnesses, and to repeat them as long as any doubt remains on the mind of any individual present. Were these rules strictly observed, physiology would cease to be perplexed by the inaccuracies in which the inexperienced and precipitate are constantly involving it.

But this has not been the only cause of perplexity in the subject I am entering on. The evil, both here and in other branches of physiology, has, in a great degree, arisen from writers either having been too apt to enter upon their inquiries and detail their experiments without having made themselves acquainted with the state of our knowledge at the time, and without having sufficiently weighed what had been done by others, even as far as they were acquainted with it; or, when little had previously been done, having drawn their inferences from too partial a view of facts. Thus, much confusion and contradiction have often been introduced even where the immediate results of their experiments were accurately observed and recorded, and they have been prevented from so directing their labours as to conduce to a gradual and steady accumulation of knowledge.

As the early physiologists present to us the results of their own imaginings, without even pretending to be possessed of any facts which directly support them; the later and more rational inquirers have, from the causes just enumerated, been often betrayed into conclusions equally erroneous; and even in making important additions to our knowledge, they have frequently done what they could to render them useless and sometimes injurious to the cause of science, which inferences, from a partial view of facts, often are, to a greater degree than those which are evidently suppositions, because they assume the semblance of legitimate deductions.

Thus it was that M. Le Gallois taught that the power of the heart is independent of the brain, but derived from the spinal marrow, and that the powers

of circulation in every part of the body depend on the corresponding part of that organ; inferences apparently supported by the facts he adduces, but wholly inconsistent with others which escaped him: and yet, at first view, so much the necessary results of his ingenious experiments, all of which were correct, that the Royal Academy of Sciences at Paris, after they had been repeated in the presence of the celebrated Humboldt and other eminent academicians appointed by the Academy to witness their repetition, adopted all his conclusions, and were for some time followed by the learned of other countries. Many similar instances might be adduced.*

In order that I may distinctly lay before the Society the nature of the first question to be considered in the following paper, it is necessary to observe that it appears from experiments detailed in papers which the Society did me the honour to publish in the Philosophical Transactions for 1815, and since republished in my Inquiry into the Laws of the Vital Functions, that the power both of the muscles of voluntary and involuntary motion is independent of the nervous system, yet in both equally capable of being influenced by it, the nervous in-

* It was thus that Haller inferred, from finding that the heart cannot, like a muscle of voluntary motion, be excited through its nerves, that this organ cannot be directly influenced by the brain and spinal marrow, an error which has more extensively influenced the practice of medicine than any other into which physiologists have led us. The fact on which this inference is founded depends not on the heart being placed beyond the direct influence of the brain and spinal marrow, but on the nature of the ganglionic nerves.

fluence being the constant stimulant in the functions of the former class of muscles, and an occasional stimulant in those of the latter, which in all their usual functions are excited by stimulants peculiar to themselves; but that these classes of muscles are influenced by it in very different ways, each of the muscles of voluntary motion being under the influence of no part of the brain and spinal marrow, but the particular part from which its nerves arise; while each of the muscles of involuntary motion is under that of every part of these organs, from the upper surface of the brain and cerebellum to the lowest portion of the spinal marrow.

In subsequent papers, published in the Philosophical Transactions, and in the Experimental Inquiry just referred to, I endeavoured to trace the final cause of this arrangement, and found that the functions, with the exception of the circulation, to which the muscles of involuntary motion administer, namely, secretion and the other assimilating processes, require for their due performance the united influence of every part of the brain and spinal marrow; while the muscles of voluntary motion are concerned in no function but that of giving motion to the different parts of the body to which they are attached, and consequently have no direct influence on the functions of life.

From the whole of the experiments on which is founded the view I have thus been led to take of the functions of the nervous system, and its relation to the different classes of muscles, it would appear that the brain and spinal marrow are the only active parts of that system; the nerves, whether cerebral or

ganglionic with their ganglions and plexuses, being only the means of conveying and combining the influence of the various parts of these organs.

But as these inferences are less direct than those arrived at in the foregoing publications, and as very different opinions have been maintained both by preceding and subsequent physiologists, it appears necessary to review this part of the subject with more care, particularly as our view of many of the phenomena, both of health and disease, must be essentially modified by it. This, therefore, is the first question I propose to consider.

The various parts concerned in the functions of the living animal may be divided into active and passive, those in which the power resides, and those which only obey that power, but which are equally essential to the function. Thus, the belly of a muscle is the active, the tendon, the passive part of the organ. In the production and application of the bile, synovia, and other fluids prepared for the purposes of the animal economy, the gland is the active, the ducts, as far as the peculiar office of the organ is concerned, the passive part of that organ; and I know of no way of ascertaining which is the active and which the passive part of any organ, but by observing which obeys the other in the function of the part.

Thus it has been pretty generally admitted with respect to what may be called the cerebral part of the nervous system, that is, certain parts of the brain and spinal marrow, with the nerves immediately proceeding from them, that the former are the active, the latter the passive parts of these organs; because we find that the power of the nerves is always pro-

portioned to the excitement of the brain and spinal marrow, as that of the tendon is proportioned to the excitement of the belly of the muscle. Even this position, however, has by some been controverted, and it has been maintained that the nerves themselves in part supply the influence on which their functions depend.

But in whatever manner this part of the question, which it will be necessary to consider more particularly, may be disposed of, there is certainly, from the more complicated structure of the parts, better reason for regarding the ganglionic nerves, with their ganglions and plexuses, as active in the formation of nervous influence, than the simple nerve which connects the cerebral mass with the muscle which it excites; and it has consequently been the opinion of many physiologists that the ganglionic system is concerned in the production of this influence, and some have gone so far as to regard it as independent of the brain and spinal marrow, and therefore the only source of the power of its own nerves.

As soon as it was found that the organs supplied with ganglionic nerves obey every part of the brain and spinal marrow, it was necessary to abandon the latter opinion, and we could see a reason for the complicated structure of the ganglionic system, independently of its supplying any part of the nervous influence. As each of the vital organs is sensible to the action of every part of the brain and spinal marrow, some apparatus capable of combining the influence of all these parts is evidently necessary, and none apparently could be better fitted for the purpose than that system which, both by its ganglions

and plexuses, and the frequent anastomoses, if I may use that expression, of its nerves, seems even at first view intended to combine the power of the various parts from which it receives nerves; and, when those proceeding from the ganglions and plexuses are found by direct experiment to convey the influence of all those parts, the inference appears almost unavoidable.

We here have a proof that the organs supplied by ganglionic nerves obey the influence of all parts of the brain and spinal marrow, and consequently that the ganglionic nerves combine and convey the influence of all those parts; and it is contrary to what we observe of the simplicity of the operations of nature that there should be another source of that influence.

In another fact we find an additional objection to such a supposition, for it appears from many experiments related in the papers and inquiry above referred to, that exactly in proportion as we increase or impair the power of the brain and spinal marrow, the functions of the ganglionic nerves are increased or impaired; still pointing out the brain and spinal marrow as the active, and the nerves with their ganglions and plexuses as the passive parts of the system; and these observations come with the more weight because those who have maintained that the ganglions supply nervous influence have not even pretended to support their opinion by any facts directly bearing on the point.

If, however, it also appears from direct experiment that the ganglions and plexuses are capable of influencing the power of the ganglionic nerves, independently of any change induced on the brain and

spinal marrow, however improbable the fact may at first sight appear, we must admit that there is in the former organs an additional source of the power possessed by those nerves.

It has been found that the action of the heart is immediately influenced by agents, whether stimulants or sedatives, affecting any considerable part either of the brain or spinal marrow.* Can its action, in like manner, be affected by agents making their impression on the ganglions and plexuses? For the purpose of determining this point, the following experiment was made, in which Mr. Cutler and Mr. Field, the well-known veterinary surgeon, were so good as to assist me, Mr. Field performing the operative part.

The heart continues to obey the effect of agents acting through the nervous system for a certain time after what we call death, that is, the removal of the sensorial powers †; and this time is much prolonged if the circulation be maintained by inflating the lungs at proper intervals; for in all modes of death, except where the nervous or sensorial system is so powerfully and suddenly impressed as at once to destroy all the functions, the nervous as well as the muscular survive the removal of the sensorial powers ‡; and the newly dead is on several accounts a better subject than the living animal for such experiments as the following, although the result is still more satisfactory if the animal can be so prepared as to destroy the

* Papers in the Philosophical Transactions for 1815, and Experimental Inquiry into the Laws of the Vital Functions.

† My paper in the Philosophical Transactions for 1829, and Experimental Inquiry.

‡ Ibid.

sensibility as far as the experiment is concerned, without so completely destroying it as to interrupt respiration, which proves that the animal still lives.*

Mr. Field partially divided the spinal marrow near the head in an ass in such a manner as to destroy the sensibility, as far as the experiment was concerned, but not to interrupt the respiration, thus bringing the animal into the best possible state for the experiment. It lay as still, and suffered as little during it, as an animal quite dead in the usual sense of the word, while the circulation was more perfect than it could be under any artificial inflation of the lungs. In another respect the state of the animal was particularly favourable, for Mr. Field succeeded in exposing the semilunar ganglion and its plexuses with a very trifling loss of blood, not I believe four ounces. The heart was then found to pulsate sixteen times in ten seconds, as ascertained by the pulsation of the arteries in the neighbourhood of the ganglion. The ganglion and its plexuses were then irritated by the point of the scalpel, and at length cut across in various directions; but although the beats of the heart were repeatedly counted during these operations, they continued uniformly of the same frequency. Spirit of wine was then applied to the wounded ganglion and plexuses, but without the least change in the beats of the heart. A strong infusion of tobacco in water was now applied, but with the same result, the beatings of the heart being still six-

* It has been shown in the publications just referred to, that in the more perfect animals respiration is as much a function of volition as the motion of a limb, and consequently ceases when the sensibility is wholly destroyed.

teen in ten seconds; nor could any variation in the force of the beats be observed in any part of the experiment.

It appears from this experiment that we cannot influence the organs supplied by the ganglionic nerves by causes affecting the ganglions and plexuses, independently of the brain and spinal marrow; and the inferences from this and the preceding facts are unavoidable, that the former organs make only a part of the channel through which the influence of the latter is conveyed; and that the peculiar office of the ganglions and plexuses is to combine the influence of the nerves which terminate and are blended in them, and send off nerves endowed with their combined influence, in consequence of which the parts which receive the nerves proceeding from them become subject to every part of the brain and spinal marrow.

Such being the case with respect to the ganglions and plexuses, it is not likely that we shall find the nerves themselves, whether ganglionic or cerebral, capable of supplying any part of the influence they convey; but that nothing may be taken for granted, this also is a point which must be determined by an appeal to facts.

It is to be recollected that here, as in other cases, the onus probandi rests with the asserter. This would still be the case, although his position were less improbable than that, while there is an evident and acknowledged source of nervous influence, and that adequate to the production of the phenomena, another source of it should exist. Those who maintain such an opinion must adduce the proofs of it. Let us inquire to what they amount.

While the connexion of the nerves with the brain and spinal marrow exists, the nerves are capable of exciting the muscles, causing the evolution of caloric which supports animal temperature, forming the secreted fluids from the blood, and supporting the other processes of assimilation by which the structure of the various organs is maintained * ; but as soon as this connexion is intercepted, all these functions begin to fail, and soon cease, nor do we possess a single fact to prove that there are any means in the nerve itself of maintaining or renewing any of them. By mechanical impulse the power which remains in a separated nerve of the cerebral class, for even this is not the case with respect to the ganglionic nerves†, may be directed to its extremities and made evident by the excitement of the muscle in which it terminates; but independently of such an impulse we have no means of exciting a nerve separated from the brain and spinal marrow, even during the short time it retains the influence it has received from those organs.‡

The very circumstance of the nerves being the means of conveying the influence of the brain and spinal marrow affords a presumption that they are not themselves the source of a similar influence.

* My paper in the Philosophical Transactions for 1829, and Experimental Inquiry.

† It is true that the heart has been excited by galvanism through the medium of its nerves; but they may here act merely as conductors.

‡ In the living animal a nerve cut off from direct communication with the brain and spinal marrow, but otherwise uninjured, will, as Sir Benjamin Brodie has shown, long retain this power, as we should *à priori* have expected. It retains its healthy structure, and its communication with other nerves.

The former is evidently their peculiar function, and it is so improbable that they should perform another of so different a nature, that it would require the most unequivocal proof of such a fact to induce its belief. The power of the nerves is not only as far as we see derived from the brain and spinal marrow, and soon ceases and cannot be renewed when they are separated from these organs, but is, as I have already had occasion to observe, at all times proportioned to the degree of excitement in them ; nor can an instance be adduced in which a cause of increased nervous power makes its impression on the nerves themselves. For its degree as well as existence, then, the power of the latter depends wholly on the former organs; and this observation applies as strictly to the ganglionic as to the cerebral nerves. The brain and spinal marrow, therefore, possess all the characteristics of the active, the nerves of the passive parts of the system.

It may appear at first sight that the phenomena of what has been termed the sympathy of nerves oppose the preceding views. On a careful review of these phenomena, however, they will be found to afford them additional support. They are all such as depend on changes in the central parts of the nervous system, and in no degree on any influence of the nerves on each other in their progress. As I have nothing to add to the statements I have already published on this subject, for the facts on which the foregoing positions are founded, I beg to refer to the 106th and 107th pages of the third edition of my Inquiry into the Laws of the Vital Functions.

Another opinion respecting the function of the nerves has been maintained, and lately by a writer of

great respectability *, which deserves to be considered, because it claims the support of experiment, and if well founded must essentially affect our opinion of the nature of the nervous influence.

Dr. Henry appears to admit the independence of the muscular power, but thinks he has rendered it more than probable that the nervous influence, instead of being only one of many agents, is the only one capable of exciting the muscular fibre; and consequently that all others act through it, so that they are not in fact stimulants to that fibre, but to the nerves alone, through which they influence it.

It is true that as mechanical impulse affecting a nerve of voluntary motion is capable, after its separation from the brain and spinal marrow, of exciting, through it, the muscle in which it terminates, and we cannot be assured that we have separated from the muscular fibre the whole of the nerves with which it is so intimately blended; if we were in possession of no other facts on the subject, we should be led to the inference, that the excitability of the muscular fibre can only be influenced through its nerves; but when instead of a mechanical we employ a chemical agent, we find the result very different. We attempt in vain to influence a muscle through the nerve which terminates in it by the most powerful agent of this description, yet such an agent when applied to the muscular fibre itself excites it as readily as the mechanical agent, which is supposed only to affect it through the nerve.

* Dr. William Charles Henry's Critical and Experimental Inquiry into the Relations subsisting between Nerve and Muscle, in the 110th Number of the Edinburgh Medical and Surgical Journal.

Even if the power of the chemical agent be gradually increased until the structure of the part of the nerve to which it is applied is destroyed, not only the muscle in which it terminates, but even the other parts of the nerve itself remain wholly unaffected. The nerve has not even the power of communicating the change to its adjoining parts. This was proved by the experiments of Fontana, and confirmed by those of Dr. Henry related in the paper just referred to.

What reason then have we for supposing, when a chemical agent applied to the muscular fibre excites it, that it operates through the nerves which still adhere to it. Such an inference implies that nerves in their progress wholly change their nature, a supposition for which there is not only not a shadow of proof, but against which the most convincing proofs which analogy can supply present themselves.

APPENDIX, N° IV.

Extracted from Vol. 42. *page* 52. *of the Journal Book of the Royal Society. February* 8. 1816.*

"It appears," says the author (Dr. Philip), "from the first of two papers already published, that the power of the heart is wholly independent of the nervous system, though occasionally stimulated by it; and from his second paper, that the same positions are equally true with respect to the larger vessels of circulation; but it remained now to be examined whether the same be also true respecting the vessels of secretion.

The general subjects of these experiments were rabbits, in which the process of digestion was interrupted by division and separation of the divided ends of the eighth pair of nerves. For though a rabbit may live twenty-four hours after the operation, any food contained in the stomach undergoes no change in appearance, and does not partake of the peculiar smell which accompanies the digestive process, but remains in the same state as parsley chopped with a knife.

Upon a presumption that the nervous influence is the same as that of galvanism, and in the hope that the want of that influence might be supplied by the substitution of a suitable galvanic apparatus, the author made many corresponding experiments on other rabbits, in which the eighth pair of nerves was divided as before; but he formed an electric circuit from one extremity of a voltaic trough through the nerves and stomach to the other extremity of the

* Mr. Roberton, the secretary of the Society, has compared the following extract with the Journal Book, and finds it correct.

trough, which was connected with the pit of the stomach. The trough employed in these experiments had forty-seven pairs of plates of zinc and copper, and was charged with a mixture of muriatic acid diluted with seven equal measures of water, and such a portion of this battery, varying from one third part to the whole of it, was employed as was found sufficient to keep up a gentle twitching of the chest and fore legs. When the battery lost its power, it was observed that the breathing became worse, till its power was restored by addition of fresh acid, and that the animals had a tendency to vomit, which was removed by means of the same increase of galvanic action.

The food also, as a consequence of this action, is stated to have lost entirely its appearance and smell of parsley, and to have undergone those changes, and to have assumed that smell, which is observable when the process of digestion is in its most perfect state.

The result of these experiments, the author thinks, cannot be explained without admitting that the nervous influence is identical with galvanism, and that secretion of the gastric fluids, on which digestion depends, is not effected by any power residing in the secretory vessels, but is the effect of decomposition and recombination produced by the agency of the nerves alone. Hence he presumed that the evolution of animal heat is also to be regarded as a secretion effected by the same power.

In the prosecution of his experiments, Dr. Philip takes into consideration the use of ganglia, and observing that the muscles of involuntary motion are supplied with nerves from ganglia, and that these parts are affected by every part of the brain and spinal marrow, he infers that the ganglia are to be regarded

as organs in which the influence of the whole brain and spinal marrow is concentrated. Hence, although it be by division of the eighth pair of nerves that the functions of the stomach are principally impeded, they also suffer, in due proportion, by depriving the great chain of ganglia of any part of their nervous influence, as the author took much pains to ascertain by a variety of experiments, in which he destroyed different portions of the spinal marrow. But when the spinal marrow instead of being destroyed was only divided, still retaining all its connections with the stomach, through the medium of the ganglia, then the digestive process appeared to him to be scarcely, if at all, impaired. Since, in the experiments on the destruction of different portions of the spinal marrow, the animals were found to be colder than natural, the author was confirmed in the supposition, that caloric is a secretion from the blood evolved by the powers of galvanism; and in consequence of this theory, he made several experiments upon the changes of temperature observable in blood taken from the carotid arteries of rabbits, and placed in a galvanic circuit. In comparison with other blood taken at the same time, and not galvanised, a difference of three or four degrees was found more in the former, accompanied with other changes dependent on the chemical agency of the battery.

As the general results of his experiments, the author infers that secretion is a function of the nervous system; that the vessels of secretion only convey fluids to be operated upon by the nerves; that in this office they obey the same laws with all other parts of the sanguiferous system. That the secreting power does not cease to act with the formation of the fluid,

but the continuance of nervous influence is essential to the vital properties of the fluid.

That the identity of galvanism and the nervous influence must be admitted.

That caloric is to be regarded as a secretion.

That the nervous influence of the stomach and lungs, like that of the heart, is derived equally from every part of the brain and spinal marrow through the intervention of the ganglia; that the ganglia are secondary centres of nervous influence.

That either the brain or spinal marrow alone may continue to supply the ganglia after the other is destroyed; that both continue to supply their share, though they be separated from each other; that the functions of those involuntary organs which are purely muscular are independent of the nervous system, while that of secreting organs are wholly dependent on nervous influence.

In concluding this paper, the author endeavours to remove the impression occasioned by the recital of experiments on living animals, which are to be justified solely on the conviction that they may essentially conduce to the welfare of society, and which even then, unless conducted with every possible regard to the feelings of the animals, cannot be too strongly reprobated.

Thanks were ordered to Dr. Philip for this communication."

The various positions stated in this paper have since been generally admitted, in consequence of a public repetition of the experiments both in London and Paris. See the fourth edition of my Experimental Inquiry into the Laws of the Vital Functions, published in 1839.

APPENDIX, N° V.

On the Sources and Nature of the Powers on which the Circulation of the Blood depends. By A. P. W. Philip, M.D. F.R.S. L. & E. From the Philosophical Transactions of 1831.

It is remarkable that, notwithstanding the great importance of the circulation in the animal economy, the length of time which has elapsed since its discovery, and the constant attention it has obtained, there is hardly any department of physiology respecting which there appears to be greater uncertainty and contrariety of opinion than the sources and the nature of the powers on which this function depends. I propose in the following paper, by comparing the principal facts on the subject, and by such additional experiments as seem still to be required, to endeavour to determine these points. Much has lately been written and many experiments have been made with this view, and it has become customary to look for the causes which support the circulation to other sources beside the powers of the heart and blood-vessels.

It has been supposed that what has been called the resilience of the lungs, that is, their tendency to collapse, by relieving the external surface of the heart from some part of the pressure of the atmosphere, is a principal means of causing it to be distended with blood, the whole weight of the atmosphere acting on its internal surface through the medium of the blood which is thus propelled from

the veins into its cavities; and in this way it has been supposed that the motion of the blood through the whole of the venous part of the circulation is maintained. A similar effect has been ascribed to the act of inspiration, which it is evident must operate on the same principle; and this opinion has even been sanctioned by the Report of a Committee of the Royal Academy of Sciences of Paris *, and in this country by men whose authority is deservedly high; and the effect of these causes, it is asserted, is increased by the elastic power of the heart itself.

However successfully such opinions might be combated by reasoning on the data we already possess, as direct experiment is the most simple as well as decisive way of determining the question, as reasoning on physiological subjects has so often deceived, and the experiments may here be made on the newly dead animal, and consequently without suffering of any kind, I have thought it better that the point should be determined in this way, especially as it is by experiments, which at first view seem to countenance the foregoing opinions, that their supporters attempt to establish them, with the effect, as it appears to me, of withdrawing the attention from the powers on which the circulation actually depends, and introducing considerable confusion respecting a question so immediately connected with the phenomena and treatment of disease.

With a view, therefore, to submit the foregoing opinions to this test, the following experiments were made, in which Mr. Cutler was so good as to assist me.

* Report on Dr. Barry's paper, by Baron Cuvier and Professor Dumeril.

Exp. — A rabbit was killed in the usual way by a blow on the occiput, and the chest opened on both sides so as freely to admit the air. The lungs were then inflated eight or ten times in the minute by means of a pipe introduced into the trachea; the circulation was found to be vigorous. On laying bare one of the femoral arteries, it was observed to pulsate strongly; and on wounding it, the blood, of a florid colour, indicating that it had undergone the proper change in its circulation through the lungs, gushed out with great force; and on introducing the hand into the thorax, the heart was found to be alternately distended and contracted as in the healthy circulation.

Exp. — All the vessels attached to the heart in the newly dead rabbit were secured by ligatures and divided, and the heart removed. It was allowed to empty itself. Its contractions continued to recur, and in their intervals it assumed a perfectly flat shape, proving that the elasticity of the heart in this animal is so small that it cannot even maintain the least cavity after the blood is discharged.

It appears from these experiments that the circulation was vigorous when none of the causes to which the motion of the blood in the veins have been ascribed existed. In the first experiment the chest being freely opened on both sides, so that the play of the lungs on inflating them could be seen, all effect on the heart either of the resilience of the lungs or the act of inspiration was evidently prevented; and in the second, it was proved that no sensible elasticity of the heart existed; yet while artificial respiration was performed we could perceive no abatement in the vigour of the circulation.

It is to be observed, that all these means can act only in one way in promoting the circulation, namely, by giving to the heart the power of suction; that is, by producing a tendency to vacuum in its cavities, in consequence of which the pressure of the atmosphere propels the blood from the veins into them, that of the arteries being prevented from returning to the heart by the valves at their origins. But all, as far as I know, who have either made experiments with a view to prove the supposed effect of these means on the circulation, or who have sanctioned the inferences from such experiments, have overlooked the circumstance that the veins being tubes of so pliable a nature that when empty they collapse by their own weight, whatever may be said of the effect of such causes in favouring a horizontal or descending motion of the blood, it is impossible that an ascending motion could be produced in them on the principle of suction. As far as the heart may possess any such power, its tendency must be to cause the vessel to collapse, not to raise the fluid it attracts.

That the resilience of the lungs, as far as they possess this property, and the act of inspiration, tend to dilate the heart and large vessels within the chest is evident; but the former is very trifling, if it exist at all, except as far as it depends on the mere weight of the lungs; and the latter in common breathing is little more efficient, although the effect of respiration on the brain, when any part of the cranium is removed, sufficiently attests that it has a certain effect. When the breathing is so laborious as essentially to influence the circulation, it evidently tends to derange the regular flow of the blood towards the heart, inspiration of course acting interruptedly;

whereas it is only necessary to inspect the chest of any of the more perfect animals immediately after death, and while artificial respiration is being performed, provided death has not been caused by great loss of blood, or an extreme and instantaneous impression on the nervous system, to see that the blood flows uniformly towards the heart with no interruption but that which the contraction of the heart itself occasions.

The elasticity of the heart is greater in some animals than in the rabbit; but it is in all cases very inconsiderable. The heart of the tortoise is the most elastic I have examined; yet even it may be compressed during its diastole by a force not sensibly greater than is sufficient to compress other muscles in a state of relaxation. Besides, the auricles possess little or no elasticity; and whatever the elasticity of the ventricles may be, it can have no effect on the blood in the veins, because they receive their blood from the auricles which are contracting during the diastole of the ventricles. To these statements it may be added, that in many of the inferior animals the foregoing supposed causes of the venous part of the circulation evidently have no existence, and that, with the exception of the elasticity of the heart, they have no existence in the fœtal state in any.

We have just seen from direct experiment, that the circulation of the blood goes on as usual when all these causes have wholly ceased to operate.

I shall now take a rapid view of the facts which, as far as I am capable of judging, leave no room for doubt respecting the sources of the power on which this function depends.

It is so evident to those in the least acquainted

with the animal economy that the contractile power of the heart is one of the chief of these sources, that it would be superfluous to enumerate the proofs of it; yet even this position has been denied, and that by a writer of no mean abilities. The opposite error, however, is the more common; and not a few have ascribed, and even still do ascribe, the motion of the blood throughout the whole course of circulation to the contractile power of the heart alone, although it would not be difficult to prove that to drive the blood through one set of capillary vessels, and still more through two or three sets of such vessels,—for in man himself, in one important part of the circulation, it is carried through two, and in some animals through three, sets of capillaries before it returns to the heart,—I say it would not be difficult to prove that to drive it through one set of capillaries, at the rate at which the blood is known to move, would require a force capable of bursting any of the vessels. But here, as in the former instance, it is better to appeal to the evidence of direct facts than to any train of reasoning; and there is no want of such facts to determine the point before us, some of which I formerly had the honour to lay before the Society, and others are stated in my Treatise on the Vital Functions. The most decisive is, that the motion of the blood in the capillaries continues long after the heart has ceased to beat, and the animal in the common acceptation of the term is dead, even in the warm-blooded animal, for an hour and a half or two hours, and it is not for some time sensibly affected by the heart's ceasing to beat; nor does this arise from some imperceptible impulse still given by the heart, because when all the vessels attached to

this organ are secured by a ligature, and the heart cut out, the result is the same.

That the circulation in the capillary vessels is independent of the heart may be shown by various other means. On viewing the motion of the blood in them, with the assistance of the microscope, it may generally be observed that it is moving with different degrees of velocity in the different vessels of the part we are viewing, frequently more than twice as rapidly in some than in others. Were the motion derived from a common source, this could not be the case. It is impossible, in the motion of the blood in the capillaries, in the least degree to perceive the impulse given by the beating of the heart, which causes the blood in the larger arteries to move more or less per saltum, the motion of the blood in the former being uniform as long as they retain their vigour, and the necessary supply of blood is afforded from the larger vessels. I have found by experiments very frequently repeated *, that the motion of the blood may be accelerated or retarded in the capillaries by stimulants or sedatives, applied either to the brain or spinal marrow, and acting not through the medium of the heart, but on these vessels themselves. Nay, so little effect has the action of the heart on the motion of the blood in the capillaries, that I have found that when the power of the capillaries of a part is suddenly destroyed by the direct application of opium to them, the motion of the blood in them instantly ceases, although the vigour of the heart and that of every other part of the sanguiferous system is entire. †

* My Treatise on the Vital Functions.

† Ibid.

If the circulation in the capillaries be thus independent of the heart, it is evident that the influence of that organ cannot extend to the veins. On comparing the whole of the foregoing circumstances, is it not a necessary inference that the motion of the blood in the larger veins, like that in the capillaries, depends on the power of these vessels themselves? But that we may not trust to any train of reasoning, where it is possible to have recourse to direct proof, I made the following experiment, with the assistance of Mr. Cutler.

Exp.—In the newly dead rabbit, in which the circulation was maintained by artificial respiration, the jugular vein was laid bare for about an inch and a half; a ligature was then passed behind the part of the vessel nearest to the head, and the animal was so placed that the vein was brought into the perpendicular position, the head of the animal being undermost, so that it was necessary for the vein, in conveying the blood to the heart, to convey it perpendicularly against its gravity. The ligature, which was placed at what was now the lowest part of the exposed portion of the vein, was suddenly tightened, while Mr. Cutler and myself observed the vessel. The blood in the part of the vein between the ligature and the heart was instantly and completely expelled, as the transparency of the vessel enabled us to perceive. The vessel itself wholly collapsed, proving that all its blood had entered the heart, so that to a superficial view there seemed to be no vessel in the part where a large dark-coloured vein had just before appeared. In the mean time, on the other side of the ligature, the vein had become gorged with blood.

In the foregoing experiment we see the blood

rising rapidly against its gravity, where all causes external to the vessel on which the venous part of the circulation has been supposed to depend, had ceased to exist, and the vis à tergo was wholly destroyed by the ligature.

By a similar experiment, the power of the arteries in propelling the blood may also be demonstrated.

Exp.—In a newly dead rabbit, the circulation being supported by artificial breathing, the carotid artery was laid bare for about an inch and a half. The animal was so placed as to keep the vessel in the perpendicular position, the head being now uppermost. A ligature was passed behind that part of the vessel which was next the heart, and Mr. Cutler and myself observed the vessel at the moment the ligature was tightened. The artery of course did not collapse as the vein had done in the preceding experiment; but the blood was propelled along the vessel, so that it no longer appeared distended with it. It was at once evident, from the change of appearance in the vessel, that the greater part of the blood had passed on in a direction perpendicularly opposed to its gravity. It is worthy of remark, that the blood of the artery was propelled neither so rapidly nor so completely as that of the vein, the cause of which will be evident in the observations I am about to make on the nature of the function and powers of these vessels.

When the whole of the preceding facts are considered, it will, I think, be admitted that the circulation is performed by the combined power of the heart and blood-vessels themselves, and that no auxiliary power is necessary for its perfect performance. Here, as in other cases, the more we study the ope-

rations of nature, the more direct and simple we find them. The resilient power of the lungs and elasticity of the ventricles of the heart, as far as they exist, favour the free entrance of the blood into these cavities, an office adapted to the feebleness of such powers, which, in many animals, we have seen, have no existence. Their operation is similar, but probably much inferior, to the elastic power of the arteries, by which the ingress of the blood suddenly impelled into them by the systole of the heart is rendered more free than it would have been had these vessels tended to collapse in the intervals of its contractions. Had the blood flowed into them in a continued stream, and been carried through them by their own powers alone, their elasticity would evidently have impeded, not promoted, the circulation through them. Thus the veins, where these conditions obtain, are so pliable that they collapse by their own weight, and hence it was that in the preceding experiments the vein carried on its blood so much more rapidly and completely than the artery, which felt the want of the impulse it receives from the heart, that at once assists in propelling its blood, and through the blood stimulates the vessel itself. The action of the vein was perfect; it possessed all its usual powers, which reside in itself alone.

It only remains for us to inquire into the nature of the power by which the heart and bloodvessels maintain the circulation. Respecting the nature of the power of the heart there cannot be two opinions. It is evidently a muscular power. The structure of its parietes is similar to that of other muscles, and they obey all the usual laws of the muscular fibre.

Is the power of the vessels of the same nature? This is a question which has frequently been discussed. The chief arguments which have been adduced in favour of the affirmative are, the nature of their function; the fibrous appearance observed in some of the vessels, which is more evident in some other animals than in man; and the minuteness of most of the vessels, which, if they are muscular, accounts for the difficulty with which the muscular structure is detected in them. The chief arguments against the muscularity of the vessels have been, that they could not be made to obey an artificial stimulus in the way that the heart and other muscles are found to do, and that their chemical analysis gives no evidence of fibrin. Of the latter of these objections Dr. Young observes, that a part may be muscular although it does not contain fibrin, and refers in support of this opinion to the crystalline lens. The former of these objections no longer exists, the vessels having been found to obey both stimulants and sedatives as readily as parts more evidently muscular. It appears from many experiments related in my Treatise on the Vital Functions, that the action of the capillary vessels is as easily influenced both by stimulants and sedatives as the heart itself; and although the larger vessels are not so easily excited artificially as the heart and muscles of voluntary motion, yet several physiologists have succeeded in exciting them both by mechanical and chemical agents. But there is another argument in favour of the muscularity of the vessels, which, I think, may be regarded as no less powerful. I endeavoured, in papers which I had the honour to present to the Society, and which appeared in the

Philosophical Transactions for 1815, to ascertain the relation which the heart bears to the nervous system, which is different from that of the muscles of voluntary motion. It appears from the facts there adduced, that this organ is not only independent of that system, although capable of being influenced through it either by means of stimulants or sedatives, and that even to the instantaneous destruction of its power, but that it equally obeys either set of agents, whether applied to the brain or spinal marrow; while the muscles of voluntary motion obey no stimulus acting through the nervous system, unless it be applied to their nerves themselves or to the particular parts of that system from which their nerves arise. I found from repeated experiments that the vessels bear the same relation to the nervous system as the heart does, their power being independent of this system, but equally with the heart capable of being influenced by either stimulants or sedatives applied either to the brain or spinal marrow, and that even to the instantaneous destruction of their power. They in all respects bear the same relation to the nervous system with the heart, which affords the strongest argument for believing that their power is of the same nature.*

From the various facts stated or referred to in the foregoing paper, the following inferences appear to be unavoidable: — that the circulation is maintained by the combined power of the heart and bloodvessels; and that the power of both is a muscular power.

* My Treatise on the Vital Functions.

APPENDIX, N° VI.

From a review of the whole of the facts which have been laid before the Society, in my paper on the Nature of Sleep, published in the Philosophical Transactions for 1833, it appears,

That in the brain and spinal marrow alone reside the active parts of the nervous system.

That the law of excitement in the parts of these organs, which are associated with the nerves of sensation and voluntary motion, is, that it is uniformly followed by proportional exhaustion, which, when it takes place to such a degree as to suspend their usual functions, constitutes sleep; all degrees of exhaustion which do not extend beyond them, and the parts associated with them, being consistent with health.

That the law of excitement in those parts of the brain and spinal marrow which are associated with the vital nerves, is excitement, which is only, when excessive, followed by any degree of exhaustion, no degree of which is consistent with health.

That the vital, in no degree partaking of the exhaustion of the sensitive system in sleep, only appears to do so in consequence of the influence of the latter on the function of respiration, the only vital function in which these systems co-operate.

That the law of excitement of the muscular fibre, with which both the vital and sensitive parts of the brain and spinal marrow are associated, is excite-

ment which, like the excitement of the vital parts of these organs, is only, when excessive, followed by any degree of exhaustion. And

That the nature of the muscular fibre is everywhere the same, the apparent differences in the nature of the muscles of voluntary and involuntary motion depending on the differences of their functions, and of the circumstances in which they are placed.

I SHALL conclude this paper with a few observations on dreaming, immediately connected with the preceding parts of the subject.

Had we, independently of experience, been made acquainted with the nature of sleep, we might have foretold that dreaming — pretty much as we find it — would be its consequence.

We here find the sensitive parts of the brain, to which the powers of mind belong, and the parts associated with them, in a state of exhaustion, but not such exhaustion as prevents their being excited by slight causes, while other parts of the system are still in a state of activity. But it is only in the most perfect state of health, and such as we rarely enjoy, that the vital functions are performed without slight causes of irritation arising in some of their various and complicated processes, which tend to disturb the repose of the sensitive parts of the brain. Thus it is that indigestion and other internal causes of irritation produce dreaming. Such causes act partially, and therefore only partially excite those parts.

It seems greatly to influence the phenomena of dreaming, that in order to favour the occurrence of sleep, and thus as far as we can prevent unnecessary

exhaustion, means are always employed at its accustomed times to prevent, as much as possible, the excitement of the external organs of sense, and consequently those parts of the brain corresponding with them. This renders us the more sensible to causes of excitement existing within our own bodies, while, by the inactivity of those parts of the brain which correspond to the organs of sense, we are deprived of the usual control over such parts of the mental functions as are thus excited, the effect of which is greatly increased by the rapidity of the operations of the memory and imagination, when not restrained by some of the various means employed for that purpose in our waking hours. These are often objects of the senses, as written language, diagrams, sounds, and sometimes even objects of touch ; but the most common is the mere use of words, independently of any object presented to our senses.

Any one may easily perceive how difficult it is to pursue a train of reasoning without this means of detaining his ideas for the purpose of steadily considering them and comparing them together. Now in sleep, in consequence of the excitement of the brain being so partial, we are deprived of all these means ; and our ideas pass with such rapidity as precludes all consideration and comparison. Our conceptions, therefore, are uncorrected by experience, and we are not at all surprised at the greatest incongruities. Why should we be surprised at our moving through the air, when we are not aware that we have not always done so? The mind of the dreamer differs from that of the infant in having a fund of ideas laid up in it which may by various circumstances be partially recalled ; but it resembles it in being in other

respects void of the results of experience, and consequently, with the exception of this partial operation of experience, of the means of correcting the ideas excited in it. In general, there is neither time nor means for doubt or hesitation.

Such is the rapidity of our thoughts in dreaming, that it is not uncommon for a dream, excited by the noise that awakes us, and which, therefore, must take place in the act of awaking, to occupy, when put into words, more than fifty times the space in the relation. It is a good illustration of what is here said, that when we dream that we are conversing, and thus obliged to employ words, the usual incongruities of dreaming do not occur. The ideas are sufficiently detained to enable us to correct the suggestions of the imagination. No man ever dreamt that he was telling another that he had been flying through the air.

Thus the peculiarities of dreaming arise from the partial operation of the causes of disturbance, and some of the sensitive parts of the brain being capable of excitement without disturbing others; and thus it is that the more near we are to awaking, the more rational our dreams become, all parts of the brain beginning to partake of the excitement, which has given rise to the adage, that "morning dreams are true."

APPENDIX, N° VII.

Extract from a Paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1836.

We have now considered individually the various powers of the more perfect living animal.* We have found in it, beside the mechanical powers which, it will be admitted on all hands, it evidently possesses in common with inanimate nature, four distinct powers; three of them vital powers, properly so called, that is, powers having properties essentially different from those of the agents which operate in inanimate nature. In the fourth alone we recognise one of those agents; for we find it can exist in other textures than those to which it belongs in the living animal, and that we can substitute for it one of the powers of inanimate nature without deranging any of the functions of life.

All these powers are employed, although in a very different way, in the construction of two systems in a great degree distinct; the end of the one being the maintenance of our bodies, of the other, our intercourse with the world which surrounds us.

In the remaining part of this paper, I am to consider the various relations those powers bear to each other in the maintenance of the foregoing systems; and the way in which these systems themselves are

* See Appendix, No. I.

so related as to form the animal body into a whole, in which no part can be affected without tending more or less to influence every other.

In order to ascertain the seat of the power on which muscular contractility depends, it was necessary in an early part of this paper to enter on the relation which subsists between the muscular and nervous systems; and it appears from what is there said, that the nervous influence, whether in its effects on the muscles of voluntary or involuntary motion, stands only in the relation of a stimulus or directly debilitating power to the muscular fibre, according to the degree and manner in which its organs are impressed, a result, I may observe in passing, peculiarly in accordance with all the other facts which have been stated respecting the nature of that influence, because the same observation, we shall find, applies to all the agents of inanimate nature which are capable of influencing the muscular fibre.

The relation which next demands our attention is that which subsists between the organs of the nervous influence and the living blood.

The first thing, which here strikes us, is that the blood-vessels and nerves uniformly accompany each other; from which we are led to infer that they cooperate in functions of very general necessity.

The powers of the nervous system, properly so called, we have seen, are of a chemical nature. Of this nature therefore must be all processes in which they immediately cooperate. It is evident that where such powers are employed, to render them efficient, materials must be provided on which they may operate, and there must also of course be means by which these materials are duly exposed to their action.

The materials we find in the blood, the means employed for the purpose of duly exposing them to the action of the nervous influence, in the capillary vessels, on which the minute extremities of the nerves, (which we know from numberless observations are those parts of the nervous system by which its powers are immediately applied in the functions of secretion and assimilation, as well as the excitement of the muscular fibre,) are distributed. As the central are the only parts of the nervous system, properly so called, employed in the formation of the nervous influence, the extremities of the nervės are the only immediate organs of its powers in all its functions.

The motion of the fluids in the capillary vessels, as appears from many of my experiments related in the Philosophical Transactions for 1815 and my *Inquiry into the Laws of the Vital Functions*, depends on a power which resides in themselves, in no degree depending on the power of the heart or arteries, except as far as is necessary for the due supply of blood to the latter, which form the reservoirs from which the capillary vessels draw their supply. When in the newly dead animal a ligature is thrown round all the vessels attached to the heart, and this organ is removed, the motion of the blood in the capillaries continues unimpaired, and only fails in proportion as the supply of blood from the large arteries fails * ; the cause of the emptiness of the latter some time after death.

By such means the materials on which the nervous

* See a paper on the Powers of Circulation in the Philosophical Transactions for 1831 republished in my Inquiry into the Nature of Sleep and Death. See also my Inquiry into the Laws of the Vital Functions, Part II.

influence operates are supplied and presented to it; and the means of supply, namely, the power of the heart and arteries, as well as that of the capillary vessels themselves, being, as we have seen, under the immediate influence of the same power which effects the chemical changes *, the supply is proportioned to the demand under the various conditions of the ever-changing functions; and under the same influence are the means of removal, whether of secreted fluids or solid parts, become unfit for the purposes of life. Such are the circumstances above referred to, which render it necessary that the muscles, whether directly or indirectly employed in these functions, should be subjected to the same power on which depend the functions of secretion and assimilation, namely, all muscles of involuntary propulsion, that is, with a very few exceptions, all muscles of involuntary motion.

It appears from some lately ascertained facts that the secreted fluids are formed from the blood while still in its vessels, and not in the act of their separation by the secreting organs. That such must necessarily be the case appears from what has been said. The act of separation must be posterior to the changes effected by the chemical powers of the nervous influence. It is only while the blood is still in its vessels that it can be exposed to their operation; and we have reason to believe that it is only as the due changes have been effected, that is, only as the secreted fluid has acquired its due properties, that it applies the due stimulus to the vessels by which it is

* See experiments detailed in the Philosophical Transactions for 1815 and 1822, and my Inquiry into the Laws of the Vital Functions, Part II.

discharged: on the same principle that the due action of the intestines, by which they discharge their contents, is not excited if these contents have not acquired their due properties by the chemical processes which take place in the stomach and duodenum.

Such are the nature and functions of the nervous power, and its relations to the muscular power and the powers of the living blood. When we turn to the sensorial system, we find ourselves in a new world. Here voltaic electricity, which we so successfully substitute for the nervous influence, can do nothing. The immediate organs of the sensorial power, we have seen, are, in their healthy functions, as it were hedged in and defended from contact with any of the agents of inanimate nature.

On the one hand, we find the nerves of sensation, which so far partake of the nature of the external world that they are capable of receiving and propagating impressions from its agents, but in all other respects are allied to the organs with which they are associated. By their vital powers they influence the immediate organs of the sensorium, and the functions thence resulting are the effects of one vital organ influencing another, and that by its vital properties alone; for it is evident that the properties operating here have nothing in common with those of any of the principles of inanimate nature. In the results, consequently, we have seen all analogy with the phenomena of these principles, for the first time, lost; and necessarily so, none of the properties of the agents of that world being immediately employed in their production.

The nerves of sensation, it appears from what has been said, convey not the nervous influence properly

so called. The influence they convey is of a nature essentially different from that by which the muscles are excited and the functions of secretion and assimilation maintained. They sufficiently partake of the nature of the sensorial organs to be capable of directly impressing them, and thus the latter receive all their impressions whether originating from without or within our own bodies.

On the other hand, — that is, that the sensorial organs may, without contact with any of the agents of the external world, impress those agents, — a more complicated machinery is required. The various nerves of sensation are the only means required for conveying impressions to these organs; but so simple an apparatus is not sufficient to convey to, and impress on, the materials of the external world, the dictates of volition. The powers of the nervous system, properly so called, are here called into operation by the sensorial powers, to which they are subjected; for it appears from many experiments, detailed in my papers in the Philosophical Transactions for 1815 and in my Inquiry into the Laws of the Vital Functions, that as the muscular is independent of the nervous power, but subjected to its influence, the nervous is independent of the sensorial power, but, in like manner, subjected to the influence of this power. In the case before us the nervous, influenced by the powers of the sensorial organs, supply a certain set of nerves with the stimulus which excites the muscles of voluntary motion, the immediate agents by which the materials of the external world are impressed.

I have had occasion to refer to the great variety of the phenomena of life, as one cause of their

apparent obscurity. Such is their variety that we are, at first view, lost in attempting any arrangement or even enumeration of them. An essential step towards their arrangement, as appears from what has been said, is their division into those which are the immediate results of the cooperation of the principle of life with the principles of inanimate nature, and those which have no immediate dependence on the latter powers; for all our functions mediately or immediately depend on the operations of the agents of inanimate nature. All are more or less directly excited by impressions originating in their agency.

The most purely sensorial functions, our pleasures and pains, are as dependent, though more remotely, on the excitement maintained by them as the functions of the organs immediately impressed by them. Have not the excitements of memory, for example, as much originated in their impressions, as their more direct effects on the part impressed? And when the nature of our bodies and the circumstances in which we are placed are duly considered, what other result could be expected? Our organs, being composed of the same materials as the world which surrounds us, can only be directly influenced by agents of their own nature; and from that world, and by the medium of those organs, all the materials, not only of our acquired knowledge*, but of our enjoyments and our sufferings, are derived.

And as on the one hand, all our functions are more or less immediately excited by impressions made by

* We are born with the knowledge which is immediately essential to our existence. The infant knows as well how to suck and how to breathe as the adult. See my paper on the Nature of Death.

the agents of the external world on organs composed of materials of their own nature, on the other, we have no power of influencing them, but through similar means. The only means of exciting our mental functions are the impressions of those agents on the organs of sense, and our only means of operating beyond our own bodies are through our organs of motion. Even when by our mental powers we influence those of other sentient beings, it is as much, though not so directly, by impressing the agents of the external world by the latter organs as when we raise a weight or throw a stone.

Such is the general outline of the vital and sensitive systems; and the manner in which the various powers of the living animal are related in the formation of these systems. By the foregoing means, the nervous power maintains the vital functions properly so called; and the sensorial power is brought to cooperate with the powers of inanimate nature, powers which have no properties in common.

It appears from the facts adduced in my paper on the Nature of Death, published in the Philosophical Transactions for 1834, that the vital and sensitive systems obey very different laws, the difference depending on the vast difference in the nature of the sensorial and nervous powers, the leading powers which pervade all their departments, and to which all their other powers are subservient.

These other powers, it appears from what has been said, are common to both; namely, the muscular power and the powers of the living blood.

In other respects also the laws of the two systems essentially differ. Nor will these differences surprise us, when it is recollected, as appears from the facts which have been stated, that while the leading power in the vital system is one of those powers which operate in the external world, that of the sensitive system not only possesses no properties in common with the agents of inanimate nature, but depends on a set of organs unapproachable in their healthy functions by any such agents.

When the facts adduced in my paper just referred to, and that on the Nature of Sleep published in the Philosophical Transactions for 1833, are duly considered, it will appear that a principal cause of difference in the laws of these systems depends on the difference of the laws of excitability in the organs of their leading powers. In those of the leading power of the sensitive system, all degrees of excitement are followed by a rapid proportional exhaustion of excitability; so that the effect of the usual stimulants of life for a few hours renders a state of inactivity essential to the maintenance of their health: while the exhaustion of the excitability of the organs of the leading power in the vital system by those stimulants is the operation of many times as many years; the one determining the recurrence of sleep, the other the natural duration of life.

Thus it is that those in whom, from habits of dissipation, extreme labour, or other causes, the excitability of the vital system is to a certain degree exhausted, but who as they approach middle life cease to be exposed to such causes, and during that portion of life, that is from thirty to fifty or fifty-five, feel little inconvenience from the effects of their early

habits,—there still being in the vital system sufficient excitability for the usual functions of life,—after this period, when the defect of excitability begins to be felt sooner or later by all, feel the effects of its expenditure which had been so profuse in early life: many striking instances of which I have witnessed. Similar observations apply to long-protracted illness, severe misfortunes, or any other cause which at any period of life in a great degree, and for a considerable length of time, tend to exhaust the excitability of the vital system, although for a certain time the individual may enjoy his usual health after such causes have ceased to operate. *

The organs of the leading power in the vital system, as appears from the facts stated in my paper on the Nature of Death, possess at birth a high degree of excitability, a degree beyond that proportion which constitutes the firmest state of health—the cause, as there pointed out, of many of the most fatal diseases of infancy. By the operation of the usual stimulants of life the excitability is gradually reduced till it bears a due proportion to those stimulants by which the powers of the constitution are confirmed. At length, from their continued operation, the fault is a defect, not a redundancy, of excitability, to which every day necessarily adds, till they can no longer excite the organs on which that power depends; for in every instance the immediate cause of absolute death, which is very different from what we call death, is the failure of that power. †
And as, in the vital system, there are no means in the

* See what is said of the excitability of the two systems in my paper on the Nature of Sleep and Death.

† My paper on the Nature of Death. Philosophical Transactions for 1834.

constitution, as in the sensitive system, of restoring the excitability of its organs, they finally cease to be excited. Thus it is that in almost all cases of great longevity we find that there has been little exposure during life to powerful causes of exhaustion of either body or mind, for we have seen that the nervous is immediately under the influence of the sensorial power; and that such instances are most frequent in the colder of the temperate climates, heat, on the one hand, tending to exhaust excitability, and extreme cold, on the other, to render us less capable of excitement.

While considering the laws of excitability, it is necessary to bear in mind an essential property of all those agents which are capable of calling it into action, and which has demanded less attention than its great importance in the treatment of disease demands. There is no agent capable of influencing either of the two systems into which the functions of the living animal arrange themselves, whether it be such as makes its chief impression on the mind or body, which is not capable of acting either as a stimulating or directly debilitating power, according to the degree in which it is applied. There is none which may not be applied in so small a degree as to act as a stimulant, and in so great a degree as to act as a directly debilitating power. The most depressing passion in a comparatively small degree will excite, the most exciting in an excessive degree directly debilitate; and the same stimulus by which either the nervous or muscular fibre is directly excited will by its excessive application directly deprive it of power. I know of no exception to this law. All medicines within their

stimulant range excite; and unless the excitement exceeds the degree which produces no correspondent depression (for such a degree of excitement is compatible with the laws of the vital though not with those of the sensitive system *), it acts as a permanent tonic. All, beyond their stimulant range, act as directly, and although within that range, if of a certain intensity, as indirectly debilitating powers with respect to both systems. †

It is evident from many facts, stated in my papers, on the Nature of Sleep and Death, that each of the foregoing systems is a whole, which cannot be influenced in any one part without a tendency to be affected in all others, a property which perhaps more than any other influences the progress of their deviations from the healthy state; for every part more or less feeling the change effected in any one, if there be any from accidental causes more liable to disease than the rest, this part particularly feels the cause which operates on all; and, as I shall soon

* My paper on the Nature of Sleep in Philosophical Transactions for 1833.

† See what is said on this subject in my treatise *On the Influence of Minute Doses of Mercury in restoring the Functions of Health*, and my Gulstonian Lectures on the more obscure affections of the Brain, also in the recapitulation at the end of this paper. All my Treatises, to which I have occasion to refer, are more or less founded on the principles here recapitulated; and consequently in them more or less copious references to the facts, on which these principles rest, became necessary. In order to arrive at the conclusions of the present paper, it was necessary to state the whole of those facts with their various bearings, which I have done in as concise a manner as the requisite perspicuity appeared to admit of. In the less familiar parts of the subject, it requires some care to avoid being misunderstood.

have occasion to point out more particularly, is even the means of diverting its effects from every other part. Thus it is that diseases of continuance become complicated, and that an affection, attended with litle risk in the part first impressed by the offending cause, often becomes formidable by its secondary effects.

The power which operates here has been termed the sympathy of parts the effects of which I have considered at length in a treatise on the more obscure diseases of the brain, being the Gulstonian Lectures delivered at the College of Physicians in 1835. I am now, after referring to its more prominent effects, to consider the nature of this function, and the powers on which it immediately depends.

As it appears from the experiments above referred to that the organs of the sensorial and nervous powers, the leading principles of the two great systems the functions of which comprehend all the functions of life, although both belonging to the brain and spinal marrow, are distinct sets of organs; the one set being confined to a comparatively small portion of these organs, the other distributed through the whole of them, from the uppermost surfaces of the brain and cerebellum to the lowest portion of the spinal marrow; and as numberless observations evince that the immediate cause of sympathy exists in the central organs alone *, it follows that these systems must have different centres of sympathy, that if the different parts of each system sympathise, it cannot be through the same centre. Now it appears from the phenomena of disease, compared with the results of the

* My Gulstonian Lectures.

experiments just referred to, that each of the centres of these systems is often influenced with so little disturbance to the other, that disease of either system, especially when of a chronic nature, often spreads to distant parts of the system in question, without much affecting the other ; a favourable result in the sensitive system, because it is only in proportion as the organs of the vital system are implicated that life is endangered ; but in the vital system the most fruitful of all causes of obscurity, and that in diseases of the most formidable nature, to which many have fallen, and still fall a sacrifice ; for so ill supplied are many of the vital organs with nerves of sensation, that in them diseases of sympathy often make a fatal progress without the state of the part originally affected having attracted attention, and without its restoration, that of the part secondarily, but more prominently, affected is impossible.* Thus also it is,—that is, in consequence of the one system often suffering with little disturbance to the other,—that much suffering not unfrequently continues for years without materially impairing the functions of life, the organs of suffering belonging to the sensitive system ; while

* The internal water in the head of children, for example, has, till within the last thirty years, been almost uniformly fatal, having been treated as an original affection of the brain. Dissection having now proved it to be a secondary affection, depending on the state of the liver, there are few serious dieases in which the treatment is more uniformly successful, if it has not been allowed to arrive at its last stage. The original affection, which does not betray itself by any prominent symptom, being removed, its consequences yield to the means, which are powerless while it continues to operate. Other affections of the head, certain forms of pulmonary consumption, and many other diseases might be adduced as illustrating the same principles.

in other instances immediate danger presents itself with so little previous suffering, that even the medical attendant is unprepared for it.

The latter evil can only be obviated by a careful study of the laws of sympathy in the vital system, and particularly by ascertaining what organs are most inclined to be affected by what others; for although the function of sympathy is, like other functions, influenced by causes peculiar to the individual, it is in a great degree regulated by principles which more or less prevail in all.*

From the facts just referred to we easily perceive the cause of the sympathy by which every part of each of the foregoing systems is capable of influencing every other. Each is regulated by a leading principle, and in consequence of this, under an influence by which the affection of any one part tends to affect all others; because as all parts of each system both influence this principle, and are influenced by it, it necessarily follows that all must, through it, — that is, through the central organs of each system, which alone are the immediate organs of its leading principle, — feel the affections of each. Such, together with the laws I am now to consider, is the source of the function to which the term sympathy has been applied, — a principle as I have just had occasion to observe, which more extensively than any other regulates the course of disease.

As each of the preceding systems is formed into a whole by its leading principle, the relations which these systems bear to each other have a similar effect with respect to the whole frame; for the affection of any one of its parts tends more or less, though much

* My Gulstonian Lectures.

less powerfully than in the individual systems, to influence all others. The means by which the relation between the sensitive and vital systems, and consequently the most complicated functions are maintained, we are here to consider; to some of them I have already had occasion to refer.

We have seen that the nervous power properly so called, the leading power in the vital system, is immediately under the influence of the sensorial power, the leading power in the sensitive system, and constitutes the medium through which all that part of our intercourse with the external world, by which the latter power influences or is influenced by it, is maintained. This, therefore, is the first bond of connexion to which I refer between the sensitive and vital systems. The second is the means by which the organs of both systems are maintained; for, as I have already had occasion to observe, the sensorial has a dependence on the vital system, for the maintenance of its organs, as the vital, we shall find, has a more remote dependence on the sensorial system for the maintenance of its organs; the connexion thus established between them being increased by both systems equally depending for the maintenance of their organs on the muscular power and the powers of the living blood; both of which are in their turn subjected to the nervous, and the former certainly, and the latter, we have reason to believe, through the nervous, also to the sensorial power.

The sympathy which prevails through all parts of each system also contributes to the influence of these systems themselves on each other; because the state of the parts secondarily affected in consequence of

the power of sympathy more or less influences both systems, all parts being more or less supplied with nerves from both.

But we have sufficient evidence in the phenomena of disease, compared with the results of the experiments referred to, that here, as in the instances just pointed out, the central organs of the sensitive directly influence those of the vital system. A sympathetic pain, it is well known, referred to any part will at length produce actual inflammation of the part. Now while the pain alone exists, we know that the derangement, which produces it, is in the central organs alone of the sensitive system, and in no degree in the part to which it is referred; and we also know, from the facts which have been stated, that there is no channel through which this derangement can influence either the nerves or vessels of the part, but through the central organs of the vital system.

When the affection of the nerves or vessels of the part is the original disease, it influences the central organs of both systems by the actual disease of the part; but in the former case there is no other channel of communication than that just referred to. The central organs of the sensitive, having no power over either nerves or vessels, can only influence them through the central organs of the vital system. Thus arises a double bond of connexion between the two systems, the central organs of the sensitive system directly influencing those of the vital system, and the sensitive system being necessarily influenced by all deviations from a state of health in whatever part, for all parts may be affected through the central organs of the vital system, the degree to which the

effect in the sensitive system takes place being proportioned to that in which the part is supplied with nerves of sensation. As the central organs of the sensitive directly influence those of the vital system, the latter, through the extremities of the different nerves with which the two sets of organs are associated, influence the former. Hence we have just seen the fatal obscurity of many diseases of those vital organs which are ill supplied with this class of nerves; and as the more chronic the disease the less it disturbs the sensitive nerves, it is in the more chronic cases that the obscurity is greatest, and consequently attended with the greatest risk.

Different parts of the central organs of the sensitive system correspond to different parts of the general frame. This is perhaps sufficiently proved by our being enabled by experience to refer our sensations to the seat of the cause which excites them; but in many of the inferior animals, where both the brain and spinal marrow partake of the organs of the sensorial power, it may be proved by direct experiment, because after the removal of the brain we find the sensorial power lost only in those parts which derive their nerves from that organ.

But how comes it that the central organs of the vital system also have relation to certain parts of the general frame, the nerves associated with these organs conveying, as appears from what has been said, their combined influence, which is bestowed alike on all vital organs?

It is a law of the animal economy, amply illustrated by the phenomena of disease, that when an impression influencing the system generally is, by previous debility or any other cause, directed to a particular

part, its operation is diverted from all others. Now it appears from a thousand phenomena that the suffering of the sensitive system, referred to any particular part, is sufficient, under certain circumstances, in consequence of the influence of the central organs of the sensitive over those of the vital system, to direct to it the effects of derangement excited in the latter. Thus even a diseased organ will often regain its healthy state when the disease has spread to another, particularly if in the latter it takes deeper root, if I may use the expression. It is a daily occurrence for a disease of function to be finally removed by a disease of structure being established in another organ. Hence the good effects of artificially exciting disease in external parts to relieve those more immediately essential to life; and the still more salutary effect when the laws of our frame themselves produce the same effect, because here it is the uninfluenced result of those laws, whereas in the former case their tendency is constrained by artificial means. Thus, for example, it is that the inflammation of a gouty joint or other external disease often relieves the derangement of a vital organ, and that artificially repelling this effort of the constitution to save a vital part has so often proved fatal.

On the facts that the central organs of the vital system directly influence the functions both of the vital nerves and of the vessels of every part, while those of the sensitive system have no direct influence on either, many of the phenomena of disease depend; because it is only in proportion as the nerves and the vessels of the part are influenced that any disease of the part itself exists, and consequently that there is any tendency to derangement either of function or

structure in the part; of function alone if the nerves alone are affected, of structure also as soon as the vessels partake of the disease. Hence it is that the tendency to change of structure, except where it takes place by imperceptible degrees, is, cæteris paribus, always proportioned to an inflammatory tendency which may be detected in the part, this tendency being the first indication that the vessels partake of the disease; and hence the importance of carefully watching and checking its approach, if the part be one essential to life, in all cases of deranged function of, or even of painful sensations referred to, particular parts.

Extensive as the foregoing relations of the vital and sensitive systems are, they are not the only ones. To determine the whole of them it is necessary to review the functions of the more perfect animals, and in particular correctly to ascertain the line of distinction between the functions of the two systems, in order to determine whether there be any beside those just pointed out in which they co-operate, and which consequently contribute to their dependence on each other.

I made many experiments with a view to draw the line of distinction between the vital and sensitive functions; and that the result might be the more certain, the attempt was made by two sets of experiments, conducted on different principles. By the one I attempted to ascertain what functions remain when the sensorial powers are withdrawn; by the other, what functions fail with the failure of the nervous powers; and the correspondence of the re-

sults of those sets of experiments tends to confirm the inferences from both.*

Much confusion had arisen from physiologists having neglected to ascertain this line. M. le Gallois, one of the most acute, soon found his difficulties from this cause such that he was obliged to confess himself unable to proceed, and leave to his successors the task of removing them. He had adduced sufficient proof of the spinal marrow, to which the nerves of respiration belong, being capable of its functions independently of the brain; yet on the removal of a part of the brain, the medulla oblongata, respiration ceases. This difficulty he acknowledges he sees no means of removing, calling it "un des grands mystères de la puissance nerveuse, mystère qui sera devoilé tôt ou tard, et dont la découverte jettera la plus vive lumière sur le mechanisme des fonctions de cette merveilleuse puissance."

If the preceding facts be kept in view, it is evident without much consideration that none of the functions of the sensitive have any other dependence on the powers of the vital system, but for the due structure and well-being of their organs. The nature of the functions of the vital system here requires more consideration. They include respiration; circulation; those processes by which the secreted fluids are formed; those, namely, the more immediately assimilating processes, by which our food is converted into the various organs of our bodies, and such parts of them as have become unfit for the purposes of life are separated and expelled, for all are in a state of change; and those by which the due temperature is maintained.

* Inquiry into the Laws of Vital Functions, Part II.

Does the sensitive co-operate with the vital system in any of these functions?

From the line of distinction, determined by the experiments just referred to, it appears that in one of them only is there such a co-operation.

I have in the last of my papers published in the Philosophical Transactions for 1829 considered at length the nature of respiration, and have, as far as I am capable of judging, adduced such facts as prove that the muscles employed in this function are, in the full sense of the word, muscles of voluntary motion. The first act in respiration is the impression made on the sensorium, the sensation excited by the want of fresh air in the lungs. We are enabled to supply it and remove the uneasiness, by exciting, through the nervous system properly so called, certain muscles subject to the will.

Respiration thus dependng on the combined operation of both systems, is as effectually destroyed by a failure of the sensation which makes us will to inspire, as by that of the nervous or muscular power by which the will effects its object. Thus the difficulty of M. de Gallois disappears. It is true that the spinal marrow and its nerves are capable of their functions iudependently of the brain, and that the nerves employed in respiration are supplied by the spinal marrow, but in this function it is an act of volition which excites them. They are quiescent till this act takes place. Hence it is that respiration ceases on the removal of the medulla oblongata, because by the removal of this part of the brain the power of sensation in all parts below the head, and consequently of volition, as far as relates to those parts, is destroyed. Hence also the fact, above re-

ferred to, that the vital has a remote dependence on the sensitive system for the maintenance of its organs. If the muscles of respiration were not in the strictest sense muscles of voluntary motion, our powers of volition would in an essential respect be imperfect; for the due regulation of their action is essential in the formation of articulate sounds, the chief means by which our sensorial powers are enabled to influence those of other sentient beings.

In the papers on the Nature of Sleep and Death, published in the Philosophical Transactions for 1833 and 1834, I have pointed out how much the functions of the more perfect animal are influenced by this peculiarity of respiration, the only vital function, properly so called, in which the sensorial power co-operates; a circumstance which more generally perhaps than any other, which is equally of a local nature, influences the phenomena both of health and disease. In this function, therefore, we find a powerful bond of connexion between the sensitive and vital systems, and one, as appears from the papers just referred to, of the most extensive operation.

Such are the means by which the frame of the more perfect animal is formed into a whole, and the function of sympathy and its more complicated functions above enumerated effected. A powerful connexion is established among all parts of each of the systems into which the functions arrange themselves, depending on each being regulated by a leading power which influences every part of the system to which it belongs, and in its turn is influenced by every part of it: and these systems themselves are intimately related in consequence of the nervous, the

leading power in the vital system, by means of the control which the sensorial power exercises over it, being employed in the accomplishment of many of the sensitive functions, and the sensorial power, the leading power in the sensitive system, in one of the most important of the vital functions; by both systems not only depending for the maintenance of their organs on the same powers, but more or less directly on each other; by those powers being under the influence of the leading principles of both; and by all affections of whatever part, whether original or sympathetic, necessarily influencing both its sensitive and vital nerves, and consequently the central organs of the system to which they belong.

From the whole of the facts referred to in the preceding paper, the great outline of the laws which regulate the functions of the more perfect animal is derived. The parts of which it consists, from the complicated nature of the subject, being very numerous, it is necessary, in order to place it in a clear point of view, concisely to recapitulate them; and as in the preceding paper I commenced with the more simple, and was, by their intimate connexion with the more complicated powers, led to them, I shall in the recapitulation, that they may be viewed in both directions, begin with the more complicated, which by the same means will lead us to the more simple powers.

Beside the mechanical powers, of which the living animal evidently partakes in common with inanimate nature, it possesses, we have seen, four distinct

powers, apparently peculiar to itself, having no direct dependence on each other, but each depending on the other three for the maintenance of its organs; the sensorial, the nervous, and the muscular powers, and the powers of the living blood.

By these powers are maintained the two systems into which the various functions arrange themselves, the vital and sensitive systems; the object of the one being the maintenance of our bodies, of the other our intercourse with the external world.

The organs of the sensorial power in man have their seat in the brain. They can be excited by no other means than the influence conveyed by the nerves of sensation, in the most extended sense of the expression, in every instance called into operation by impressions made on their extremities by agents which belong to inanimate nature, either existing within our own bodies, or making their impression from without; and, on the other hand, there are no means by which the sensorial organs can influence those agents but through the intervention of the powers of the nervous system properly so called. The nature of the sensorial power, we have seen, admits of no direct intercourse between its organs and the agents of inanimate nature, because it operates by properties, which have nothing in common with those of such agents; and as its organs can only receive impressions from the external world through the nerves of sensation with which they are associated, it can only impress the agents of that world through the muscles of voluntary motion, excited by the nerves associated with them. Thus it is necessary, as we have by direct experiment found to be the case, that the organs of the nervous system should

be placed under the control of the sensorial power. Through the same channel, we have seen, this power also, in some of their functions, controls the muscles of involuntary motion; and we have reason to believe, although the point has not been ascertained by direct experiment, all the powers of the living blood. And such, as appears from facts above referred to, is its influence on the nervous, and through it on the muscular power, and we have reason to believe on the powers of the living blood, that it can not only excite, but impair and instantly destroy all these powers, according to the nature and power of the causes which influence its organs.

The circumstance of the muscular, as appears from facts above referred to, being the moving power of the blood in the vessels as well as the heart, greatly extends the influence of those powers which control it, namely, the nervous power properly so called, and the sensorial power acting through it.

The only respects in which the sensorial power is related to the subject of this paper are in the impressions it receives from the nerves of sensation, and the functions in which it co-operates with the nervous and muscular powers. Sensation and volition are the only sensorial powers employed in the maintenance of life.

While the organs of the sensorial power are thus capable of more or less directly influencing all the other organs of the living animal, they more or less feel in their turn, through the medium of the nerves of sensation, which we have seen convey an influence of wholly a different nature from that conveyed by the nerves associated with the organs of the nervous power properly so called, all changes effected in any

part of our frame. By these means this power constitutes the leading principle in the sensitive system, of which its organs form the central parts.

The organs of the nervous power, properly so called, have their seat equally in the brain and spinal marrow, and throughout all parts of them; and are excited, on the one hand, by the direct influence of the sensorial power, and on the other, by agents influencing the vital organs throughout every part of the frame; all of which, as in the case of the impressions made on the nerves of sensation, whether existing in our own bodies or making their impression from without, are agents of inanimate nature.

The immediate functions of the unaided nervous power are the excitement of the muscles of voluntary motion in all their functions, of the muscles of involuntary motion in some of their functions; and the immediate functions of this power in co-operation with the muscular power and the powers of the living blood, all the powers of both of which are directly subjected to its influence, are the formation of the secreted fluids, the maintenance of animal temperature, and the various more immediately assimilating functions, — namely, the functions by which, on the one hand, our food is converted into our various organs, and, on the other, those parts of them which have become useless are separated and expelled, — which render it necessary that the muscles of involuntary motion, as far as they co-operate in these functions, which with few exceptions include the whole of these muscles, should, as we have seen from direct experiment is the case, be under the immediate influence of the nervous power.

Neither the brain nor spinal marrow in the functions of the vital system acts through the other of these organs, as the brain is found to do through the spinal marrow in many of those of the sensitive system; each directly influencing every part.

The direct influence of the nervous power, it appears from what has been said, extends to all the functions of the system, with the exception of those of the sensorial power, which it only influences through other functions. It directly influences, and is directly influenced by, all the vital functions, properly so called, and hence constitutes the leading principle of the system to which they belong, therefore termed the vital system, of which its organs form the central parts.

The circumstance of each of the foregoing systems being under the influence of a leading power, which is both capable of influencing and being influenced by every part of it, is the cause of that powerful sympathy which exists among all its parts; and which we have seen often essentially influence either system with but little disturbance to the other, on which many of the most important phenomena of disease depend.

The muscular power, which has its seat we have seen in the muscular fibre itself, and the powers of the living blood, which have their seat in the blood itself, perform subordinate parts. They are equally employed in both systems for the maintenance of their organs. The latter supplies the materials endowed with the principle of life on which the nervous power operates in the formation of the secreted fluids,

the maintenance of animal temperature, and the various more immediate functions of assimilation; while the former, to which the vessels as well as the heart owe their power, supplies the means by which these materials are duly exposed to the operation of the nervous power, by which their necessary changes are effected; that is, to the influence of the extremities of the nerves, by which the nervous power operates in all these functions, as well as in the excitement of the muscles; for as the brain and spinal marrow, as we have seen proved by direct experiment, are the only parts of the nervous system employed in preparing the nervous influence, the minute extremities of the nerves are the only immediate organs of its functions; as the extreme parts of the sanguiferous system, the capillary vessels, are the organs by means of which the blood is immediately exposed to its influence.

That the capillary vessels may be as little as possible influenced by adventitious causes in functions of such importance in the animal economy, we find, on the one hand, as appears from experiments above referred to, that the motion of their blood depends wholly on their own powers, the larger arteries which depend for their supply of blood on the heart being only the reservoirs from which they draw their supply; and that, on the other, they are not controlled by the nervous influence through the medium of the heart, but receive this influence directly from its source; and so correct are these positions, that even the removal of the heart, if effected without considerable loss of blood, produces no immediate effect either on the action of the capillaries, or the control which the nervous power exercises over them.

Such are the individual powers of the living animal, their seat, the relation they bear to each other, and the manner in which their several functions are effected.

But the most complicated functions, it appears from what has been said, depend on the relations which subsist between the two systems themselves, into which the functions of all these powers are arranged.

They are related to each other, we have seen, by the nervous, the leading power in the vital system, in consequence of the control exercised over it by the sensorial, the leading power in the sensitive system, being employed in many of the functions of the latter; by the sensorial being employed in one of the most important of the vital functions, this peculiarity of respiration, for in no other of those functions is there any such co-operation, extensively influencing the phenomena both of health and disease; by both systems depending for the maintenance of their organs on the same powers, namely, the muscular power and the powers of the living blood, and more or less directly on each other; by the powers common to both systems being under the influence of the leading powers of both; and by all affections of whatever part necessarily influencing both its sensitive and vital nerves, and consequently the leading powers of both systems.

As the various parts of each system are formed into a whole by all parts of each influencing and being influenced by its leading principle, so all parts of the animal body are formed into a whole, no part of which can be affected without tending more or

less to affect all others, by the means just enumerated, by which these systems influence each other. Such are the foundations on which the laws of sympathy depend, a principle which, as I have endeavoured in a cursory way to point out, more than any other, influences the course of all deviations from a state of health.

THE functions of all the powers of the living animal, we have seen, are mediately or immediately excited by agents belonging to inanimate nature. Our organs are composed of the same materials with the external world, and can only be immediately impressed by agents of their own nature. It is true that the sensorial functions are the results of one vital part acting on another, the sensitive nerves on the immediate organs of the sensorial power; but the impression these nerves convey is in every instance received from the agents of inanimate nature. Here both the agent and the organs impressed are of the same general nature, being composed of similar materials with our other organs. The peculiarity of the results depends on vital properties alone being employed in their production, whereas in all other functions of the living animal, the vital properties of the organ co-operate with the properties of the materials of which it is composed. Hence it is that its functions admit of being immediately excited by the agents of inanimate nature, which, having no properties in common with the only properties employed in the sensorial functions, cannot directly co-operate in their production.

Every agent capable of exciting any of the functions of the living animal, we have seen, acts as a

stimulant or directly debilitating power, according to the degree in which it is applied. In the sensitive system their stimulant effect is always followed by a proportional exhaustion of excitability; in the vital system, only when the excitement exceeds a certain limit. I speak of a sensible exhaustion, an exhaustion beyond that produced by the usual stimulants of life, which, in the vital system, is too gradual to be perceived, and as far as relates to any particular stimulant employed within such limit is so trifling that it may be safely overlooked. Hence it is that the vital system appears to possess an excitability which is not exhausted by stimulants except when applied in excess. It is essential, we have seen, in the treatment of disease to keep in view these properties of all agents capable of influencing the functions of life, that we may, as much as the nature of the case admits of, keep within the stimulant range of our remedies; and within that range, as far as possible, avoid the degree of excitement which produces sensible exhaustion of the vital organs.

Thus it is that all agents which maintain such excitement of the vital organs as is within the range of the excitement here termed moderate act as permanent tonics.

With respect to the nature of the powers of the living animal which we have been considering, the sensorial and muscular powers and the powers peculiar to living blood we have found belong to the living animal alone, all their peculiar properties being the properties of life. The functions of life may be divided into two classes, those which are effected by the properties of this principle alone, and those, by

far the more numerous class, which result from the co-operation of these properties with those of the principles which operate in inanimate nature. The nervous power we have found to be a modification of one of the latter principles, because it can exist in other textures than those to which it belongs in the living animal, and we can substitute for it one of those principles without disturbing the functions of life.

Late discoveries have been gradually evincing how far more extensive than was supposed, even a few years ago, is the dominion of electricity. Magnetism, chemical affinity, and (I believe, from the facts stated in the foregoing paper, it will be impossible to avoid the conclusion) the nervous influence, the leading power in the vital functions of the animal frame properly so called, appear all of them to be modifications of this apparently universal agent; for I may add, we have already some glimpses of its still more extensive dominion.

In the preceding paper my chief objects have been to review the whole of the functions of the more perfect animal, to ascertain the nature of the powers on which they depend, the seat of each of these powers, the manner in which they are employed in effecting their several functions, and the manner in which they are associated in producing their more complicated results. Nothing in any part of the subject has been taken for granted, no position having been advanced without a reference

to the observations or experiments on which it is founded.

I have here for the first time made an attempt, which could not be done till all the facts on the subject had been ascertained, to point out the manner in which the different powers of the living animal influence each other, and thus conduce to their more complicated results; by which, being enabled to analyse these results, it might easily, were this the proper place, be shown, that we better see the operation of its different powers in the various deviations from a state of health, and can, under certain circumstances, better regulate the means of obviating them.

APPENDIX, N° VIII.

Extract from a Paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1816.

In the prosecution of an inquiry in which I have been engaged for several years, some of the results of which were published in the Philosophical Transactions of last year, I have had occasion to make many experiments relating to the effects of voltaic electricity, which seem to me to point out, with more precision than has yet been done, what we are to expect from it in the cure of disease; and I think it will appear from what I am about to say, that to the want of discrimination in its employment we must ascribe the little advantage which medicine has hitherto derived from the discovery of this influence.

It seems to be an inference both from my own experiments and observations and those of others, which I had the honour to lay before the Society in my first paper, that what is called the nervous system comprehends two distinct systems, the sensorial, and the nervous system properly so called. Now it does not appear, that voltaic electricity can perform any of the functions of the sensorial system, yet in the greater number of instances in which it has been used in medicine, it has been expected to restore the sensorial power. It has been expected to restore hearing, and sight, and voluntary power. It may now and then happen in favourable cases, from the

connexion which subsists between the sensorial and nervous systems, that by rousing the energy of the latter we may excite the former. It would be easy to show, that we have little reason to expect that this will often happen. It also appears from the experiments to which I allude, that voltaic electricity has no other power over the muscular system than that of a stimulus; we are, therefore, to expect little more advantage from it, in diseases depending on faults of the sanguiferous system, than from other stimuli. Hence its failure in tumours, &c. But I cannot help regarding it as almost ascertained, that in those diseases in which the derangement is in the nervous power alone, where the sensorial functions are entire, and the vessels healthy, and merely the power of secretion, which seems immediately to depend on the nervous system, is in fault, voltaic electricity will often prove a valuable means of relief.

As soon as this view of the subject presented itself, I was led to inquire, what diseases depend on a failure of nervous influence. The effect on the lungs of dividing the eighth pair of nerves answered the question respecting one of the most important diseases of this class. We find that withdrawing a considerable part of the nervous influence from the lungs produces great difficulty of breathing. When the effect of this experiment on the lungs is carefully attended to, it will be found, I think, that it is in all respects similar to the disease which may be called habitual asthma; in which the breathing is constantly oppressed, better and worse at different times, but never free, and often continues to get worse, in defiance of every means we can employ, till the patient is permanently unfitted for all the active duties of

life. The animal in the above experiment is not affected with the croaking noise and violent agitation which generally characterise fits of spasmodic asthma. This state we cannot induce artificially, except by means which lessen the aperture of the glottis.

I found from repeated trials, that both the oppressed breathing and the collection of phlegm, caused by the division of the eighth pair of nerves, may be prevented by sending a stream of voltaic electricity through the lungs. That this may be done with safety in the human body we know, from numberless instances in which it has been applied to it in every possible way.

Such are the circumstances which early led me to expect relief from voltaic electricity in habitual asthma. It is because that expectation has not been disappointed, that I trouble the Society with this Paper. Although its effects in habitual asthma have been witnessed by many other medical men, I have mentioned nothing in the following pages which did not come under my own observation.

I have employed this agent in many cases of habitual asthma, and almost uniformly with relief. The time, during which it was applied before the patient said that his breathing was easy, has varied from five minutes to a quarter of an hour. I speak of its application in as great a degree as the patient could bear without complaint. For this effect I generally found from eight to sixteen four-inch plates of zinc and copper, the fluid employed being one part of muriatic acid and twenty of water, sufficient. Some require more than sixteen plates, and a few cannot bear so many as eight; for the sensibility of different individuals to voltaic electricity is very different.

It is curious, and not easily accounted for, that a considerable power, that perhaps of twenty-five or thirty plates, is often necessary on first applying voltaic electricity in order to excite any sensation ; yet after the sensation is once excited, the patient shall not perhaps, particularly at first, be able to bear more than six or eight plates. The stronger the sensation excited, the more speedy in general is the relief. I have known the breathing instantly relieved by a very strong power. I have generally made it a rule to begin with a very weak one, increasing it gradually at the patient's request, by moving one of the wires from one division of the trough to another, and moving it back again when he complained of the sensation being too strong. It is convenient for this purpose to charge with the fluid about thirty plates.

The voltaic electricity was applied in the following manner. Two thin plates of metals about two or three inches in diameter, dipped in water, were applied, one to the nape of the neck, the other to the pit of the stomach, or rather lower. The wires from the different ends of the trough * were brought into contact with these plates, and, as observed above, as great a power maintained as the patient could bear without complaint. In this way the galvanic fluid was sent through the lungs, as much as possible in the direction of their nerves. It is proper constantly to move the wires upon the metal plates, particularly the negative wire, otherwise the cuticle is injured in the place on which it rests. The relief seemed much the same, whether the positive wire was ap-

* I found a trough of the old construction answer better than the improved pile, which is so much superior for most purposes.

plied to the nape of the neck or the pit of the stomach. The negative wire generally excites the strongest sensation. Some patients thought that the relief was most speedy when it was applied near the pit of the stomach.

The electricity was discontinued, as soon as the patient said that his breathing was easy. In the first cases in which I used it, I sometimes prolonged its application for a quarter of an hour, or twenty minutes, after the patient said he was perfectly relieved, in the hope of preventing the early recurrence of the dyspnœa; but I did not find that it had this effect. It is remarkable, that in several who had laboured under asthmatic breathing for from ten to twenty years, it gave relief quite as readily as in more recent cases; which seems to prove that the habitual difficulty of breathing, even in the most protracted cases, is not to be ascribed to any permanent change having taken place in the lungs.

With regard to that form of asthma which returns in violent paroxysms, with intervals of perfectly free breathing, I should expect little advantage from galvanism in it, because, as I have just observed, I found that the peculiar difficulty of breathing, which occurs in this species of asthma, cannot be induced in animals, except by means lessening the aperture of the glottis. It is probable, that in the human subject the cause producing this effect is spasm, from which indeed the disease takes its name, and we have no reason to believe, from what we know of the nature of electricity, that it will be found a means of relaxing spasm.

APPENDIX, N° IX.

Extract from a Paper which the Royal Society of London did me the honour to publish in their Philosophical Transactions for 1834.

From the experiments which have been laid before the Society (Philosophical Transactions for 1822, 1827, and 1829, and my Experimental Inquiry, Part II. chap. xii.), we have reason to believe that the effects of artificial respiration in restoring those whose breathing has been interrupted till the sensibility is destroyed would be greatly aided by the use of voltaic electricity sent through the lungs in the direction of their nerves, and that many might thus be restored in whom inflation of the lungs alone fails. The inflation of the lungs in such cases acts in two ways. It gives to the blood of the smaller vessels of the lungs some of the arterial properties by which they are often excited, and, acting through the blood of these vessels, it communicates to that of the larger vessels, and of the heart itself, more or less of the same properties, independently of the blood already changed being moved on towards this organ; for M. Le Gallois has shown that after the circulation has permanently ceased the blood may, to a certain degree, be changed by inflating the lungs, not only in the trunks of the pulmonary veins and the heart itself, but even in the great arteries.

There is reason to believe, from the whole of my experiments, that the lungs should not be inflated

more than eight or ten times in the minute, and that the injection of large quantities of air and great force in its injection should be avoided, and consequently the patient placed in the position in which the chest expands with greatest ease.* One of the chief defects of artificial breathing is, that in it the chest is expanded by the pressure of the injected air, whereas in natural breathing the air enters in consequence of its expansion. But the most essential difference between natural and artificial breathing in such circumstances is, that there cannot, till recovery is far advanced, be the proper supply of nervous influence, the due action of the vital parts of the brain and spinal marrow only being restored in proportion as the due force of circulation returns. Now it appears from what is said in the Philosophical Transactions for 1822 and 1827, and more fully in my Inquiry into the Laws of the Vital Functions, that voltaic electricity sent through the lungs in the direction of their nerves is capable of performing as perfectly as that influence itself the part which belongs to it in respiration, which is so essential that the more perfect animal always dies from impeded respiration if the nervous influence be withdrawn from the lungs, unless voltaic electricity be supplied, which enables it

* Experiments relating to the Effects of Artificial Respiration in the Newly Dead Animal: Experimental Inquiry, Part II. chap. xii. If the air be thrown in more frequently or in greater quantity than the remaining powers of the lungs are capable of employing, it acts as a cooling process and is highly injurious. It is one of the defects of artificial respiration that we cannot tell either the precise quantity of air or the frequency of its injection required by the particular state of the circulating system in the lungs. We know that in the case before us the demand cannot be equal to what it is in health.

to breathe as well as when the nervous influence is entire.

A proper apparatus, therefore, for sending voltaic electricity through the lungs in the direction of their nerves and in due power should be added to the other means of resuscitation, which would render them, and probably to a great degree, more successful. The force of this observation will be perceived when it is considered that it is at the time of the first application of the remedies that the chance of recovery is greatest, and consequently that the immediate application of the whole means of healthy respiration, as far as we possess them, is of most consequence. It appears, from what has been said, that the due functions of respiration cannot be restored till the due degree of nervous influence is supplied, and this cannot happen from inflation of the lungs till the due force of circulation returns. Now the fact, explain it as we may, is, that voltaic electricity so perfectly supplies the place of the nervous influence in the lungs, that their functions are equally perfect under the influence of either. The one can only be supplied at an advanced period of recovery, that is, in fact, only in those cases where the success of our endeavours can be secured by other means; the other is, in all cases, within our reach on the instant.

APPENDIX, N° X.

Extract from a Paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1827.

The Royal Society did me the honour, in 1822, to publish the results of some experiments, from which it appeared that the secreted fluids of animals are so deranged by dividing the nerves of the secreting organs, and separating the divided ends, that they are no longer capable of their functions; and that after these functions are thus destroyed, they may be restored by transmitting voltaic electricity through the secreting organs by the portions of the divided nerves attached to them.

In the statement of these results, the attention was chiefly directed to the function of the stomach. In the present communication I shall make a few additional observations respecting the lungs.

However much the secreting surface of the stomach may be deranged by the means just mentioned, its appearance, owing we have reason to believe to the extreme minuteness of its structure, is the same, or nearly so, as when the nerves have been left undisturbed; and with the exception of occasional efforts to vomit, no symptom shows itself after the division of the nerves indicating the derangement of function which has taken place. Both in the symptoms and appearances after death, the derangement occasioned

in the lungs by their division is much more remarkable.

Soon after the operation the animal begins to breathe with difficulty, and this symptom gradually increases, and is at length evidently the cause of death. On inspecting the lungs after death, the air tubes and cells, as far as they can still be traced, are found filled with a viscid fluid ; and in a considerable proportion of the lungs, generally more or less according to the time the animal has survived the operation, every trace of both tubes and cells is obliterated, the lungs both in colour and consistence assuming much of the appearance of the liver. The portions of lungs thus changed sink in water ; and although examined with the greatest care, and the aid of a powerful magnifying glass, both by Mr. Cutler, who was so kind as to give me his assistance, and myself, we could not perceive in them the least remains of the structure peculiar to this viscus.

I wished however to ascertain, by means less fallacious than the sight, whether the structure of the lungs in the parts most affected be really so changed as to cause the obliteration of their cavities. Mr. Cutler, at my request, was so obliging as to make the following experiments, the account of which I shall give in his own words : —

" If you cut out a portion of each of the eighth pair of nerves in the neck of a rabbit, it seldom dies within eight hours, and rarely survives more than twenty-four hours.

" On examination after death, the lungs are found, in many parts, covered with dark red patches.

" To ascertain the mischief done to the substance of the lungs, I endeavoured to fill them with mercury

by the trachea, but from the delicate structure of the air cells a rupture took place, and the mercury escaped.

"I then endeavoured to inject the air cells through the trachea with the finest vermilion injection. In the healthy lungs the attempt was invariably successful, making the whole of a bright scarlet colour, and, on cutting into them, every part was found to be uniformly filled with the injection.

"After injecting the diseased lungs, the dark red patches remained on their surface: other parts of the lungs were of a bright red colour: some parts were partially injected, and other parts retained their natural appearance.

"This was explained on dissection. Those parts of the lungs which were completely injected had not suffered from disease, other parts had suffered sufficiently partially to obstruct the injection, while some parts were so completely hepatised that not a particle of injection could enter them, or the parts beyond them, which were not equally diseased.

"Those portions of the lungs which were completely injected, sunk in water, from the weight of the injection.

"The hepatised portions, from their diseased state, sunk also, whilst the portions beyond them, having their natural appearance, floated."

If, as I have repeatedly ascertained, and various gentlemen have witnessed, after the nerves are divided, and the divided ends separated, the due degree of voltaic electricity be transmitted through the lungs by those portions of the nerves which remain attached to them, no affection of the breathing supervenes, and the lungs, after death, are found quite healthy, unless

the electricity has been applied of such power, or continued for such a length of time, as to excite inflammation, and *then the appearances on dissection are those of inflammation, not those produced by the division of the nerves of the lungs.*

It appears from these facts, that the effect of dividing the nerves of a vital organ, and separating the divided ends, is not merely that of deranging its secreting power, but *all those powers on which its healthy structure depends;* and that the effect of voltaic electricity is that *of preserviny all these powers.* It is particularly to be observed, that the voltaic apparatus should be so arranged, that its influence may be transmitted through the lungs as soon as the nerves are divided, the delay of even a short time appearing to give rise to more or less morbid appearance in the lungs.

The present Paper may be considered as the concluding part of an inquiry in which I have been engaged for many years, two Papers relating to which the Royal Society did me the honour to publish in the Philosophical Transactions for 1817 and 1822.* To the first of these papers I have already had occasion to refer; the other was entitled, "On the effects of voltaic electricity in restoring the due action of the lungs." The objects of this inquiry were to ascertain how far the nervous power is essential to the function of secretion, and the other assimilating processes of the animal body; and whether the voltaic electricity, ap-

* The contents of these Papers have, with the consent of the President and Council of the Royal Society, been re-published more in detail in the third edition of my Inquiry into the Laws of the Vital Functions.

plied as far as possible in the same way in which the nervous power is applied, is capable of supplying its place in these processes. It appears from the various experiments, the results of which have now been laid before the Society, that the answer in both instances is in the affirmative.

APPENDIX, N° XII.

Extract from a Paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1828.

No arguments are necessary to convince us of the importance of that function on which all parts of our frame depend for their nourishment. In one respect its organs may be regarded as of greater importance than even those which are more immediately essential to life. The sympathies of the stomach and first intestine are both more powerful and more extensive than those of any other part, and consequently more generally and in a greater number of ways contribute to the cause, and influence the course, of all our more serious diseases.

I am induced to trouble the Society with the following observations, in the hope that I shall be able to place before them some points relating to the function of the stomach in a clearer point of view than has hitherto been done. In former papers which the Society have done me the honour to publish, and more fully in a Treatise on the Vital Functions, I have endeavoured by experiment to trace the different steps of the process of digestion in the stomach. It appeared that the food remains in a quiescent state, except that the part of it which lies next the stomach, as soon as it has undergone the effect of the gastric juice, is, in consequence of food thus prepared exciting a peculiar action in the muscular fibres of this

organ, carried on towards the pylorus; through which it is propelled into the intestine, the next portion of food thus brought into contact with the stomach undergoing the same process, and so on, till the whole is in a state proper for that part of the digestive process which belongs to the first intestine.

Thus the muscular fibres of the stomach are in continual action during its function; for the gastric juice pervading the contents of the stomach to a certain extent, the change effected by it on each particular portion of the food is nearly completed before the food is actually in contact with the stomach, as may be seen by inspecting that of an animal killed a few hours after a meal, and consequently is not detained when in contact with it. There is therefore a continual motion of the food in contact with its surface towards the pylorus, and the less digested part is continually approaching its surface.

It follows then that a failure of the function of the stomach may arise either from a proper gastric juice not being supplied, or the muscular power of the stomach failing to carry onward the digested part, and thus regularly to present to the stomach a new surface of food, to be acted upon by that juice. It further appeared, that for the first of these purposes the power of the nervous system is necessary, the secretion of gastric juice failing as soon as the stomach is deprived of any considerable part of this power; but that the nervous power is not necessary for the other, the muscular power of the stomach still carrying on towards the pylorus any digested food which happens to be in it, or any food which had been acted upon by gastric juice which happened to be in it at

the time, however much its nervous power be impaired; and this office is, as far as we can see, as readily performed as when the nervous power of the organ is entire.

The muscular fibres of the stomach therefore are stimulated by its contents, in the same way as those of the heart by the blood, the usual action of both being wholly independent of the nervous system, an inference which has been confirmed by many other experiments.

I have, as appears from the papers which the Society have done me the honour to publish, attempted to go a step further, and to show experimentally that the office of the nervous power in preparing the gastric juice, may be correctly imitated by exposing the living stomach to the influence of a voltaic pile after the supply of nervous power is interrupted. Those who were at first inclined to doubt this fact, have since publicly acknowledged, on witnessing the experiments, that the digestive process of the stomach supported by voltaic electricity is, as far as we can see, as perfect as that supported by the nervous power itself.

It is therefore evident, that, in the formation of the gastric juice, a chemical power can be substituted for that of the nervous system. I do not mean that, strictly speaking, its formation is to be regarded as a mere chemical process, because it is only in a living stomach that galvanism can have such an effect; but this effect bears too strong an analogy to other chemical results to be wholly separated from them.

The same effect, and one certainly of a very complicated nature, is here produced by the nervous power and a chemical agent; because, when the latter

is substituted for the former, the same effect takes place. It is a simple matter of fact. But it is maintained by some gentlemen, that the same effect may be produced by a mechanical agent.* They have related several experiments which appeared to them to prove, that when after a part of the eighth pair of nerves is removed, and thus the due secretion of gastric juice prevented, it may be restored by mechanically irritating the cut ends of the lower portions of the divided nerves. If such be the fact, it must materially influence our views both with respect to the function of digestion and the other secreting processes of the animal body.

In judging of the result of such experiments, several things must be taken into the account which appear to have escaped the attention of those gentlemen.

At the time the animal is fed, in preparation for the experiment, there may be some food in the stomach, from previous meals, more or less digested, and there is always some gastric juice ready to act on any new food which may be presented to it. It is evident therefore, that although the secretion of gastric juice ceases at the moment of the excision of part of the eighth pair of nerves, some digested food must be found in the stomach for some hours after the operation; for, as I have ascertained by numerous trials, many hours are required in such experiments for the stomach to propel into the intestine the remains

* See a paper entitled, Mémoire sur le mode d'action des nerfs pneumogastriques dans la production des phénomènes de la digestion. Par MM. Breschet et Milne Edwards (lu à la Société Philomatique, le 19 Février 1825).—Extract des Archives générales de Medécine.

of food previously digested, or that digested by the gastric juice previously formed.

When therefore the contents of the stomach are examined in five or six hours, and generally even in ten or twelve, after the operation, more or less digested food is found lying next the surface of the stomach. But when the animal survives the operation eighteen, twenty, or more hours, undigested food alone is found in it. The cause of so long a time being required wholly to expel the food, which has undergone any degree of the digestive process, appears to be, that as digested food alone excites that action of the stomach which propels it into the intestine, and the more perfectly it is digested, it excites this action the more readily, the last part of the digested food which has but imperfectly undergone the digestive process is expelled very slowly, so that it is very long before food wholly undigested alone is left.

That the longer the animal lives after the excision of part of the eighth pair of nerves, the less digested food is left in the stomach, is a fact now admitted by all who assisted at the experiments. Among the great number who have witnessed and been satisfied with their result, are Sir Humphry Davy, Mr. Thomas Andrew Knight, and Sir Benjamin Brodie, gentlemen whose experimental accuracy, in the opinion of the public, has never been surpassed.

Of this fact, the gentlemen to whose paper I have referred, are not aware. They maintain, indeed, that the only effect on the digestive process produced by the excision of part of the eighth pair of nerves is, that it becomes more tedious, being as perfect as when the nerves are entire, if a sufficient length of time be af-

forded. In speaking of the animals in which part of the eighth pair of nerves has been cut out, and comparing them with the healthy animal, they say: "Enfin, si on laisse écouler une espace de temps plus grand encore entre l'opération et la mort des animaux, on pourra trouver que la digestion est complétement achevée dans l'un comme dans l'autre cas."

It will easily be perceived to what errors, respecting the effect on digestion, of depriving the stomach of the office of the eighth pair of nerves, this misconception must lead. Its effect was increased in the experiments referred to, by the different animals in each experiment having been confined to the same quantity of food. The most hungry would of course digest it fastest and most perfectly. To judge fairly of the result of the experiment, the different animals must be allowed equally to satisfy their appetite, to eat till, from their manner of eating, it is found that the appetite has equally abated in all.

Such are the circumstances which I conceive misled those gentlemen who maintain that they can produce a sensible effect on the contents of the stomach by any mechanical irritation of its nerves.

They also err in supposing that the muscular fibres of the stomach can be excited by irritating the eighth pair of nerves in the way that a muscle of voluntary motion may be excited through its nerves. The digested food is the natural stimulus of the muscular fibres of the stomach in its usual function, as the nervous power is of the muscles of voluntary motion in theirs; and we cannot through the nerves excite the former as we do the latter class of muscles. The muscular action of the stomach resembles that of

other hollow muscles, in being excited by its contents.

The mechanical irritation employed by those gentlemen, in endeavouring to excite the digestive process after a portion of the eighth pair of nerves had been removed, was that of a thread attached to the cut extremities of the lower portions of the eighth pair of nerves and fastened to the neighbouring muscles, by which the motions of respiration kept the part in a state of constant irritation.

In my Treatise on the Vital Functions a similar experiment is related, in which the cut extremity of the lower portions of the nerves was fastened to a thread tied round the neck of the animal, by which it was in like manner kept in a state of constant mechanical irritation ; yet in the stomachs of the animals after they had lived more than twenty hours — for the experiment was made more than once — nothing but undigested food was found. This experiment, with some others connected with it, was made publicly in the rooms of the Royal Institution, and all who felt an interest in the subject admitted to see the results, nor was there one who expressed a doubt respecting them.

As, however, in the experiments just mentioned the position of the nerves was more disturbed, and the thread was not applied as in the experiments to which I have referred, Mr. Cutler, at my request, was so good as to make the following experiment : — Three rabbits, after a fast of the same duration, were fed in the same way. In two of them a portion of each of the eighth pair of nerves was removed. The third rabbit was left undisturbed. In one of those in which the portions of nerves were removed, the cut

end of the lower part of the nerves was by means of a bit of thread fastened to the neighbouring muscles, as in the experiment referred to. This rabbit died in ten hours, at which time the others were killed in the usual way.

Mr. Cutler then took out the stomachs of all of them, slit them open, and laid them on the same plate; and Sir Benjamin Brodie was requested to examine and give his opinion respecting their contents, without having been told which was which. He at once pointed out the healthy stomach, the whole contents of which had undergone the action of the gastric juice. After carefully examining, and with an instrument moving about the contents of the other stomachs, he declared he could discover no difference in them. Both stomachs were chiefly filled with undigested food, the animals not having lived long enough after the operation for the expulsion of some imperfectly digested food that still remained in both.

The foregoing experiments convinced those who witnessed their results, that the irritation caused by the attachment of the cut end of the nerves to the muscles, had no effect whatever in promoting the digestion of the food.

Were it possible, as in the case of the nerve of a muscle of voluntary motion, to excite the eighth pair to perform its office after its communication with the brain is wholly intercepted, it is surely impossible that this could go on for many hours, which are necessary for the digestion of the food. A nerve of voluntary motion, if kept in a state of excitement after its separation from the brain or spinal marrow,

loses its power in a very short time, at most a few minutes.

The result of the foregoing experiment may be known before the death of the animals. It appears from what was said in other papers which I had the honour to lay before the Society, and which were published in the Philosophical Transactions, that the effect of the excision of part of the eighth pair of nerves on the lungs, as well as on the stomach, is obviated by voltaic electricity, the animals (the dog and rabbit were those on which the experiments were made) breathing under its influence as freely as in health. It is clear, that if the power of the nerve be restored, its restoration must be as evident in the function of the one organ as the other, these nerves being equally essential to both. In the foregoing experiments both the animals were affected with extreme dyspnœa, the mechanical irritation of the nerves having no more effect in relieving this symptom, than in promoting the due action of the stomach.

As the gentlemen above mentioned never attempted a reply to the foregoing statements, we have reason to believe that they admit the inaccuracy of their inferences.

APPENDIX, N° XIII.

Extract from a Paper which the Royal Society of London did me the honour to publish in the Philosophical Transactions for 1829.

Of the sensorial functions, sensation and volition are the only ones which we are called upon to consider here, because they alone have any share in maintaining animal life. That these functions are essential to the maintenance of life in all the more perfect animals will, I think, appear from what I am about to lay before the Society.

The following may be regarded as the nervous functions properly so called. The excitement of the muscles of voluntary motion, by which, through the intervention of the nervous system, they in their usual functions are subjected to the sensorial power; the occasional excitement of the muscles of involuntary motion, by which, under certain circumstances, the sensorial power is also capable of impressing them through the nerves, particularly when under the influence of the passions; the act of causing an evolution of caloric from the blood, by which the due temperature of the animal body is maintained; the act of forming from the blood the various secreted fluids, and of maintaining the other assimilating processes by which the healthy structure of every part of the body is preserved.

The first of these functions is universally acknowledged to be a function of the nervous power, pro-

perly so called; but there has been much difference of opinion respecting the way in which it operates. The older physiologists believed that the muscles derive their power from the nervous system. Haller* was the first who taught that the muscular power belongs to the muscle itself, to which the nervous power bears no relation but that of a stimulus, and endeavoured to support those opinions by experiment. His opponents, however, objected to his inferences, because, although the division of the nerves may prevent the muscle from receiving more nervous power, it does not deprive it of that already bestowed upon it, either existing in the muscular fibres themselves, or dispersed through them in nerves too small to be removed; and this objection appeared to be strengthened by the muscles of involuntary motion, whose function is supported by stimuli peculiar to themselves, being still supplied with nerves, of the use of which Haller gave no satisfactory account. It appeared to me that the question could only be determined by some experiment capable of directly ascertaining whether the excitability of muscles is maintained by the influence they receive from the nerves, or impaired as by other stimulants. On trial, the latter was found to be the case. Muscles whose nerves had been divided, sustained the action of the same stimulus longer than those whose nerves were entire, and which consequently were exposed to the action both of the nervous power applied by the will of the animal and the artificial stimulus.† The power of the muscle, therefore, is

* Element. Physiolog.

† My Treatise on the Vital Functions, 3d. edition. Exper. 34, 35.

independent of the nervous power, and is affected by it in the same way as by other stimuli.

The experiments by which all the other functions just mentioned, with the exception of the maintenance of animal temperature, have been ascertained to be functions of the nervous power, I have laid before the Society, which has done me the honour to publish them. From these experiments it appeared that the functions in question were always destroyed by depriving their organs of the influence of the nervous system. That the maintenance of animal temperature is a function of the nervous system, properly so called, appears from a variety of facts generally known, —the temperature either of a part or of the whole body being lessened by any cause that impairs the action of particular nerves in the former instance, or of the whole nervous system in the latter. The question then is, is the nervous system capable of all these functions after the sensorial power is withdrawn?

At the moment of what we call death, the sensorial functions cease; the animal no longer feels or wills. Whether the nervous functions properly so called still continue, can only be determined by experiment. That the nerves when stimulated are still capable of exciting the muscles of voluntary motion, is a fact generally admitted; and that they are still capable of exciting the action of the muscles of involuntary motion, appears from many experiments related in the second paper which I had the honour to present to the Society, and which was published in the Philosophical Transactions of 1815. That the nervous system is capable of causing the evolution of caloric, which supports animal temperature after the sensorial power is withdrawn, appears from many experiments

related in my treatise on the Vital Functions; and that the nervous power under the same circumstances is still capable of forming the secreted fluids, and supporting the other processes by which the structure of every part is maintained, is shown by very frequently repeated experiments on the newly dead animal related in the same treatise. From these experiments it appears that some secretion of gastric juice takes place after what we call death, and that some derangement of structure in the lungs may be produced by dividing the eighth pair of nerves immediately after death; a proof that the processes on which the structure of the part depends continue for some time after the sensorial power can no longer influence them.

We may thus trace the existence of the whole of the nervous functions, properly so called, after the removal of the sensorial power. The former, therefore, have no immediate dependence on the latter; but in the entire animal we know that the nervous, in many of its functions always, and occasionally in all of them, is subjected to the sensorial power. These powers, therefore, bear the same relation to each other that the nervous and muscular powers do, the muscular existing independently of the nervous, but being influenced by it.

It was this independence of the functions properly called nervous on those of the sensorial power, and the analogy which subsists between the former and chemical processes, which suggested that the agent on which the nervous functions immediately depend, instead of being peculiar to the living animal, may only be an agent employed by those powers which are so, in the same way as any other constituent part which the living animal possesses in common with

inanimate nature; and it appeared to me that the accuracy of this suggestion would be placed beyond a doubt if the nervous power could be proved to be capable of its function, after it had been made to pass through any other conductor than the nerves; for it will be admitted that the powers peculiar to the living animal can only operate, and, as far as we see, can only exist, in the organs to which they belong. The brain cannot perform the office of a muscle, nor a muscle that of the brain.

If, then, the nervous power can be made to pass through any substance but that of the nervous system in which it resides, it evidently has an existence independent of the mechanism of that system, and therefore is not peculiar to it. This, after many vain attempts, I succeeded in effecting. It appears from experiments, an account of which the Society did me the honour to publish in 1822, and which have been repeated with the same result by M. Brechet and other physiologists at Paris, that the nervous power is capable of its function after it has been made to pass through other conductors than the nerves.

It would seem, therefore, that however generally the nervous power has been confounded with those powers more strictly called vital, it is only an agent employed by them. This view of the subject seemed to point out the possibility of finding some of those powers which operate in inanimate nature capable of the functions of the nervous power properly so called, if brought to operate under the same circumstances; and on trial it was found, as appears from experiments published in the Philosophical Transactions of 1822 and 1828, and repeated with the same result

by Dr. Abel*, M. Breschet †, and others, that voltaic electricity may be substituted for the nervous power, not only in the more simple, but in the more complicated functions of that power. It not only appears that this form of electricity is capable of exciting the muscles and causing an evolution of caloric from arterial blood ‡, but of forming the secreted fluids from the blood, and supporting all those functions on which the structure of the body depends. How far do the whole of these facts, whether relating to the nature or functions of the nervous power, go in proving its identity with voltaic electricity?

On reviewing what has been said of the relations of the sensorial, nervous, and muscular powers, the question naturally arises: If both the nervous and muscular powers are thus independent of the sensorial power, and capable of their functions after it is withdrawn, why do the more perfect animals for so short a time survive the loss of the sensorial functions? The cause is, that on the removal of the sensorial power respiration ceases; because this function partakes of all the three powers, the sensorial, nervous, and muscular.

It has been customary to speak of the muscles of respiration as, at least in part, muscles of involuntary

* The London Medical and Physical Journal for May, 1820, vol. xliii. p. 385.

† De l'Influence du Système Nerveux sur la Digestion Stomacale; par MM. Breschet, D.M.P., chef de Travaux Anatomiques de la Faculté de Médecine de Paris, etc.; H. Milne Edwards, D.M.P.; et Vavasseur, D.M.P. (Mémoire lu à la Société Philomatic la 2 Aûot, 1823.) Extrait des *Archives Générales de Médecine*, Août, 1823.

‡ My Treatise on the Vital Functions, third edition, Exper. 80, 81, 82, 83, 84, 85, 86.

motion. What is meant by a muscle of voluntary motion? It is a muscle whose action under all ordinary circumstances we can excite, interrupt, retard, and accelerate at pleasure; but it is not a muscle whose action we can at all times control. There is no such muscle, because the impression on the sensorium tending to call any particular set of muscles into action may be so powerful that we are unable to control it. Who can prevent the action of the muscles of the arm when fire is suddenly applied to the fingers? Neither do we mean by the term muscle of voluntary motion one which we cannot call into action during sleep. If our posture during sleep becomes uncomfortable, we call the muscles both of the trunk and limbs into action for the purpose of changing it. The uneasiness caused by the continuance of the same posture sufficiently rouses the sleeper to make him will a change of posture, without rendering him at all more sensible to other impressions of a slighter nature, and his sleep continues.

What muscles, then, are more under command than those of respiration? We can on all usual occasions interrupt, renew, retard, or accelerate their action at pleasure; and if we cannot interrupt it for as long a time as that of the muscles of a limb, this depends on no peculiarity in the action of these muscles, but on the nature of the office they are called on to perform; and if we excite them in sleep for the removal of an uneasy sensation, and cannot control them under a sense of suffocation, that is, in a state of greater suffering than we can voluntarily bear, all this is no more than applies to every other muscle

of voluntary motion: but from the nature of our constitution we must breathe many times every minute, and we need not turn ourselves more than once in many hours, — a difference depending on circumstances which have nothing to do with the nature of the muscles we employ in either of these acts.

If we find the breathing going on in apoplexy after all voluntary motion of the limbs has ceased, it is because the sensation exists which calls on the patient to inflate his lungs, while there is none which calls for the action of the limbs. In the slighter states of apoplexy, if the limbs be much irritated the muscles which move them will also be called into action; and in the severer states, if the patient breathes when no irritation of the limbs can excite him to move them, it is that the want of wholesome air in the lungs, after a certain interval, produces a more powerful impression than any other means we can employ. People have voluntarily held the hand in the fire, but no man ever voluntarily abstained from breathing till the lungs were injured. When at length no irritation, however violent, can impress the sensorium, the breathing ceases and death ensues. The mode of death illustrates what is here said. We find the intervals of breathing becoming longer before it ceases. As the insensibility increases, a greater want of fresh air is necessary to excite the patient to inspire, till at length the total privation of fresh air no longer producing any sensation can no longer excite this effort.

The muscles of respiration then, it would appear, are as perfectly muscles of voluntary motion as those of the limbs, and are never excited but by an act of

the sensorium. When there is no feeling to induce us to breathe, the breathing ceases.

That on ordinary occasions we are unconscious of this feeling in the common acceptation of the term (that is, that it makes no lasting impression on the mind, for this is necessary to what we mean by consciousness), unless the attention is particularly directed to it, is no proof that it has not existed. When we direct our attention to the act of breathing, especially if we breathe more slowly than usual, we can distinctly perceive the sensation which induces us to inspire, and that it is a voluntary act which relieves it.

The same observations respecting consciousness apply to all the more trivial habitual acts of the sensorium. In playing on an instrument, we cannot tell which finger last struck the chord; in walking, we cannot tell which leg we last moved;—yet all such acts are strictly acts of volition. When we attend to them we can regulate them as we please; but in proportion as they are habitual we attend to them the less, and therefore least of all to the act of respiration.

To the consciousness of having experienced any feeling, it is evident that its strength, or some other circumstance attending it, must be such as to impress it on the memory. We are every hour performing many acts of volition which are too trivial to be remembered, and consequently at the time we are questioned we have no consciousness of their having existed. The proper feeling excites the act required, but the feeling is too habitual to command the attention.

It may be difficult for a person not accustomed to

reflect on such subjects to believe that every time his leg is moved in walking he performs a distinct act of volition; but he will be convinced of this if he observes the motions of those whose power of volition is impaired by disease. He will find the patient hesitate which leg to move at every step, and at length his attempts to move the limbs produce a confused and irregular action incapable of carrying him forward.

The act of expanding the chest is an act of volition; it is an act in ordinary breathing rendered extremely easy by the gentleness of the motion required, and the continual habit which renders it familiar, and is excited by a sensation proportionably slight, but which is as essential to it as stronger sensations are to more powerful acts of volition. Thus it is that on the removal of the sensorial power respiration ceases. It may be here said, perhaps, that we have no instance of a muscle of voluntary motion continuing to act at short intervals during life; but besides that this is begging the question, it is to be recollected that the action of the muscles in ordinary respiration is very slight, and performed at considerable intervals, for it is only during inspiration that the muscles act. They are quiescent during expiration, which in our usual breathing is performed by the elasticity of the cartilages and the weight of the parts concerned. There is perhaps no muscle of the body which could not without fatigue maintain a similar action, were there a cause capable of exciting it. In certain diseases we find both more powerful and more frequent actions of the muscles of volition continued for years, during the whole of our waking hours, without any complaint of fatigue.

When the change in the blood effected by respiration no longer takes place most of the pulmonary vessels lose their proper stimulus, red blood, and feel more directly, perhaps, the debilitating influence of black blood; their functions, therefore, begin to fail. In proportion as this happens the blood accumulates in the lungs. The right side of the heart consequently experiences an increased difficulty in emptying itself, and the due supply of blood to the left side fails. By the operation of these causes both sides of the heart, particularly in warm-blooded animals, soon lose their power after respiration ceases. The arteries under such circumstances, it is evident, cannot long supply fluids proper for the purposes of assimilation. The nervous and muscular solids, therefore, deviate from the state necessary for the functions of life, which at length cease in every part.

The foregoing appears to be the order in which the functions always, with the exception of their instantaneous destruction as above mentioned, cease in death; whether it be occasioned by injury of the sanguiferous or nervous system, or both.

Such, then, appears to be the nature of respiration. The first act is the impression made on the sensorium, the sensation excited by the want of fresh air in the lungs. We are enabled to supply it, and thus remove the uneasiness, by exciting certain muscles subjected to the will. Through nerves which are fitted for this purpose, we apply a stimulus to certain muscles which perform the act required. Thus respiration is the combined act of the sensorial, nervous, and muscular powers. It is as effectually destroyed by a failure of the sensation which makes us will to inspire, as by that of the nervous or muscular powers

by which the will effects its object. With this view of the subject before us, and I can see no other which the facts admit of, it will be proper to examine the nature of respiration more in detail.

I have already had occasion to observe, that the effort made in ordinary breathing is very slight. It is chiefly performed by the diaphragm, by the contraction of which the cavity of the chest being slightly enlarged perpendicularly, the pressure of the atmosphere readily causes the air-cells to be distended with air; but if any obstacle occurs tending to prevent the passage of the air to the cells, a greater effort is required, and other muscles are called into action. It seems almost unnecessary to observe, that the sensation which induces us to make this greater effort must, as the object is still the same, operate in the same way. The more powerful sensation indeed, and the trouble the effort gives us by calling our attention to it, enables us at once to perceive that it is an effort of the same kind with any other voluntary effort by which we endeavour to relieve ourselves from a painful feeling, and, like any other powerful voluntary effort long continued, produces the feelings of fatigue. Would any privation of air induce the struggle that we see in severe dyspnœa, if no sensation were excited by it? This sensation is excited in the sensorium through the sensorial nerves of the lungs, and all that follows is evidently the result of it.

The effort consists in two things — drawing the air into the chest with greater force, that is, expanding the chest more forcibly that the air may enter it with a greater degree of atmospheric pressure, and thus any obstacle to its entrance be overcome; and doing

all we can to enlarge the passage by which the air enters.

The action of the muscles, by which these objects are effected, has been ascribed to a particular sympathy supposed to exist between certain nerves. But if the eighth pair of nerves, which supplies the lungs, originate near the nerves of the diaphragm and certain muscles of the face by which the nostrils are expanded, this cannot be said of the nerves of many other muscles equally called into action in severe dyspnœa, the muscles of the loins, &c. ; and if we could, by what is called sympathy of nerves, explain the phenomena in question, it is not to be overlooked that the same sympathy must exist with respect to the abdominal as thoracic viscera, for the same nerves supply both.

We must therefore look for another principle to account for the relation which subsists between such acts and peculiar states of the lungs. The principle is at hand. The sensation which induces us to inspire forms a necessary link in the chain of causes ; for every contraction excited in the muscles is evidently calculated to relieve this sensation in one of the two ways just pointed out. It either tends to expand the chest, or enlarge the passage of the air. It is impossible in such a case to overlook the act of the sensorium, which is sufficient to account for the phenomena without any particular sympathy of nerves, which on the other hand, I have just had occasion to point out, is insufficient for this purpose.

The muscles employed in extreme dyspnœa are not confined to a particular set. They are the whole muscles of the trunk, and sometimes many of the limbs also ; muscles which have nothing in common,

except that they are all muscles of voluntary motion, and bear the same relation to the nervous and sensorial systems which all other muscles of voluntary motion do. Actions of the muscles of the face, indeed, are equally associated with sensations referred to the abdomen and the limbs, and arising from causes operating in them. Who can have a placid countenance while in agony from the operation of any cause, to whatever part applied?

It appears, from a great variety of experiments to which I have referred, that organs supplied with ganglionic nerves are subjected to the influence not of any one, but of every part of the brain and spinal marrow. No inference, therefore, can be drawn respecting the sympathies of any ganglionic nerve, as the term is here used; that is, a nerve that either enters or proceeds from ganglions, according to the sense in which I use the term, from any particular distribution of nerves, or from the part where any particular nerve which contributes to the power of the ganglionic system originates. Vital organs are equally connected with every part of the brain and spinal marrow; and if we must not look for those partial sympathies with respect to their other functions, there is still less room, it is evident, to look for them in those functions where the sensorial power is concerned.

The sensorium evidently residing and operating at the source of nervous power, there receives the various impressions conveyed by the nerves of sensation, and there influences those nerves which convey its dictates.

I shall beg leave to conclude this paper with a short recapitulation of the principal points which

appeared to be ascertained by the experiments referred to in it.

The nerves are divided into two classes, whose functions essentially differ; those proceeding directly from the brain and spinal marrow, which in the one direction convey the influence of the parts of those organs from which they have their origin, and are the sole means of exciting the muscles of voluntary motion, and in the other, impressions which influence the sensorium; and the ganglionic nerves, which, while they, being bound up with nerves of sensation, also convey impressions to the sensorium, and occasionally excite the muscles of involuntary motion, usually excited by stimuli peculiar to themselves, have for their principal function one of greater importance, and which requires the combined influence of the whole brain and spinal marrow, — that of supporting the various processes of secretion and assimilation, — and are consequently in the strictest sense vital organs.

Although the nervous power, therefore, stands only in the relation of a stimulus to the muscular fibre, whether of voluntary or involuntary motion, in no degree contributing to its power, which depends on its own mechanism, it is essential to the existence of the secreting and assimilating powers, which are immediately destroyed by withdrawing its influence.

Such is the relation which the nervous system bears to what may be termed the circumference of the animal body, in contradistinction to the sensorium, which may be justly regarded as its centre, to which that system bears a relation of equal importance; for it may be regarded as the means of connecting the

organs of the sensorium with all other parts. In its power this system is independent of the sensorium, for we have seen it capable of all its functions after the sensorial power is withdrawn; but in all of them it is influenced by it, constantly in some, occasionally in others. It therefore bears the same relation to the sensorial organs which the muscles bear to it. As the muscular is independent of the nervous power, so is the nervous of the sensorial power. As the nervous influence all the muscular functions, those of the muscles of voluntary motion in all their functions, those of the muscles of involuntary motion occasionally; so the sensorial influence all the nervous functions, those of the cerebral and spinal nerves in all their functions, those of the ganglionic nerves occasionally. Thus all the functions of the nervous and muscular systems, by which we are connected with the world that surrounds us, are constantly subjected to the sensorial power; while the functions on which our life depends, with the exception of respiration, are only occasionally so, and under circumstances in which the will has no control. With this exception, the latter are all functions of the nervous and muscular powers alone. To respiration the sensorial power also is necessary, and therefore the nervous and muscular powers never long survive the loss of the sensorial power.

The nervous power, which connects all the other powers of the animal body, effects so many changes in it, and has so large a share in connecting it with the world around it, cannot, strictly speaking, be regarded as one of the vital powers of that body, but as an agent employed by those powers; because it has been proved by direct experiment that it is capable

of existing independently of the mechanism of the part in which it resides, and therefore is not peculiar to that mechanism ; and, by the same means, that all its functions may be performed by voltaic electricity, made to operate in the same circumstances in which the nervous power operates.

The experiments referred to in the foregoing paper suggested its use in those diseases which arise either from a partial or general failure of the nervous power ; and the success which has attended its employment has afforded another proof of its capability of the functions of that power. The diseases in which it has been chiefly employed are habitual asthma, the various forms of indigestion, affections of the spinal marrow, and general nervous debility. An account of its effects in the first of these diseases was laid before the Society, and published in the Philosophical Transactions of 1817. An account of its effects in the others is published in the third edition of my treatise on the Vital Functions.

THE END.

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